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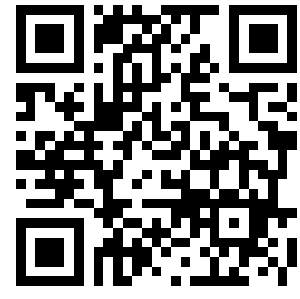

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INDEX TO "THE ELECTRICIAN."

VOL. XXII.

Leading Articles and Editorial Notes.

(In this Section LEADING ARTICLES are shown in Capitals.)

Abnormal Magnetisation, Dr. Oliver Lodge on, 183.
Allendale, Enterprising, 37.
Alternate-Current Wattmeters, 212.
AMALGAMATION OF THE TELEPHONE COMPANIES, THE, 682.
ANGLO-CONTINENTAL CABLES, THE, 592.
Arc Lamps, Prof. S. P. Thompson on, 500.
Arc Lighting, Cost of, in America, 268.
Armature, A 46ft., 1.
AURORA BOREALIS, THE, 338.
Australia, Development of Electrical Engineering in, 1.
Barnet, 156.
Battery Transformers, M. Paul Hoho on, 211.
Beam of Light, A, as a Conductor, 697.
Bell Patent Litigation, 35.
Birmingham Exhibition, The, 448, 556.
Blackpool Tramway, The, 156.
Board of Trade Inquiry, The, 609 641.
Board of Trade, The, and the Electric Lighting Companies, 211, 239, 388, 555.
BUSINESS, ELECTRICAL, IN AMERICA, 538.
Cablegrams, The Coding of, 582.
Candle-Power, Determination of, from the Current, 268.
Candle-Power of Incandescent Lamps 358.
Cape Cable, The Completion of the, 726.
CENTRAL STATION LIGHTING AND THE BOARD OF TRADE, 76.
Chelsea Electricity Supply Company, The, 95, 123.
Cheltenham, 527.
CHRISTMAS GREETINGS, 222.
City, The, Lighting of, 473.
City and Guilds Old Students' Association, The, 66.
City and Southwark Subway, The, 358, 501.
Cleveland Electric Heating Hoax, The, 327.
Compass, The, Superseded, 239.
Condensers, The Employment of, in the Distribution of Electricity, 672.
Conductivity of a Vacuum, The, 212.
Conflict of the Systems, The, in the United States, 296.
Constant-Current Regulation by means of Steam-Pressure, 422.
Continental Cables, The, 184, 448, 501, 525, 582, 611, 642.
Contract, A Singular, 725.
Copper Crisis, The, 500, 525.
Copper Wire, Deterioration of, by Electric Currents, 357.
Cowpen, The Lighting of, 156.
Death by Electricity, 213.
Deptford, Accident at, 643.
Derby, The Electric Light at, 208.
Dog-Killing Experiments, Mr. Harold P. Brown's, 35.
Dublin Corporation, The, and the Electric Lighting Scheme, 156.
Earth, The Use of, for Electric Lighting Purposes, 610.
EDISON LAMP PATENTS, THE, 458.
Edison Patent, An, 35.
Edison Patents in the States, Validity of, 326.
Edison's New Method of Potential Regulation, The, 581.
Edison-Swan Case, The, Judgment in, 447.
Edison-Swan Company, The, and the Sunbeam Lamp, 643.
Edmunds' System of Electrical Distribution, The, 95.
EIGHTEEN HUNDRED AND EIGHTY-EIGHT, 250, 278.
ELECTION OR NOMINATION? 194.
ELECTRIC LIGHTING IN THE METROPOLIS, 566.
Electric Lighting Stations in Europe, Prof. Forbes on, 500, 581.
Electric Motors, The Design of, 296.
Electric Omnibus, Mr. Radcliffe Ward's, 124, 358.
Electric Railway Subway, The Proposed, 296.
Electric Signalling for Naval Purposes, 240.
Electric Sugar, 2, 268.
ELECTRIC TRACTION, 136.
Electrical Coast Communication, 422.
Electrical Quackery, 698.
Electricity Meters, Prof. Forbes on, 325.
Electricity, Modern Views of, 1.
"ELECTRICITY, OUR DEFENCE," 14.
Electricity Supply Companies, The, and their Masters, 326.
Electrolytes, The Resistance of, 555.
Electrostatic Measurement of Potential, The, Sir Wm. Thomson on, 421.
Elieson Company, The, 727.
"ETHER, ELECTRICITY, AND PONDERABLE MATTER," 308.
EXHIBITIONS, THIS YEAR'S, 708.
Feeders, The Use of, 581.
Flashed Filaments, Prof. Silvanus Thompson on, 268.
Fog, The Electric Dissipation of, 267, 295.
French Dynamos, 698.
Fyfe-Main Company, The, 2.
Ganz Alternate Current Motor, The, 671.
Gas and Electricity, A Method of Reconciling, 124.
Gas Explosions, The, in the New York Conduits, 672.
Gas Interest, The Alarm of the, 2.
Geyer-Bristol Meter, The, 124.
Globular Lightning Stories, 222.
Harrow, The Lighting of, 473.
Helmholtz's Jet of Steam Experiment, 239.
Hempen-covered Submarine Cables, 422.
High Tension Currents, An Experiment with, 184.
Hookham Meter, The, 357.
Hopkinson Three-wire Patent, The Purchase of, 725.
Insulation Resistance of Installations, The, 387, 421.
International Congress of Electricians, Programme of, 155.
INTERNATIONAL ELECTRICAL CONGRESS OF 1889, THE, 166.
Ipswich, Working of the Electric Lighting Act at, 123.
Isolated Plants *v.* Central Station Service, 474.
Kensington Court Draft License, The, 1, 36.
KENSINGTON VESTRY, THE, AND THE ELECTRIC LIGHT, 400.
Lahmeyer Potential Regulator, The, 581.
Lead-covered Cables, The Durability of, 555, 697.
Leamington, 296.
Leyden Jar Discharges, Dr. Oliver Lodge on, 499, 525
Light without Heat, Prof. Brackett on, 357.
Lightning Conductors, Dr. Lodge on, 726
Lightning Conductors, Observational, 2, 641.
LITIGATION AND ARBITRATION, 432.
Lodge, Dr., Remarkable Experiment of, 525.
London Chamber of Commerce, Annual Report of the, 557.
London Chamber of Commerce, The Electrical Section of, 582, 610, 641.
Low-reading Commercial Voltmeter, Prof. Ayrton's, 474.
Magnetic Action of Displacement Currents in a Dielectric, The, 499.
Magnetisation of Iron, Action of Light upon the, 555.
Maxwell's Theory, A Crucial Test of the Truth of, 525.
Measurement of "e," The, 448.
Mendacity, Physical Science a Cure for, 67.
Metropolitan Electric Supply Company, The, 36, 557.
Mining and General Electric Light Company, The, 97.
Mining World, The, Electrical Knowledge in, 3.
Morse Instrument, An Improved, 500.
"Municipal Review," The, and Electric Light Contractors, 240.
"NATURE" ON "PRACTICAL MEN AND ELECTRICAL UNITS," 654.
Northfleet, The Series Line at, 526.
Ohm Memorial, The, 448.
OURSELVES, 15.
Overhead Wires, 211, 325, 725.
OVERHEAD WIRES FOR ELECTRIC LIGHTING, 46.
PACIFIC CABLE CONFERENCE, THE, 106.
Pacific Cable Scheme, The, 35, 65.
Paddington Vestry, The, Prof. Forbes' Report to, 641.
Paddington Vestry, The, Mr. Mackie's Report to, 183.
Paris Municipality, The, and the Electric Light, 556.
PARLIAMENT AND THE TELEGRAPHS, 622.
Patent Laws of the United States, The, 388.
Patey, Mr. C. H. B., Death of, 583.
Patten System of Multiplex Telegraphy, 422.
Phonopore, The, 582.
Photographic Study of Self Induction, The, 388.
Piccadilly, A Power-station near, 725.
Popp's, M., Scheme of Electrical Distribution, 556.
Practical Standard of Light, A, 267.
Quartz as an Insulator, 673.
Race Meetings and Telegraphy, 698.
Rates to the Continent, The New, 611, 642.
Reporters, Exclusion of, at the Institution, 325.
Rowlands', Prof., Experiment on the Magnetic Effect of Convection Currents, 155.
Secondary Batteries, The Electrolyte used in, 726.
Sewage, The Electrolytic Treatment of, 583.
Sheffield, Successful Central Station at, 184.
Shelford Bidwell, Mr., on the Election of Council, 825.
Silver, The Electro-Chemical Equivalent of, 698.
SOCIETY OF ARTS TRIALS OF MOTORS FOR ELECTRIC LIGHTING, THE, 484.
Society of Telegraph Engineers, The Council of, 123, 155.
Sodium, Metallic, Economical Production of, 97.
South Africa, Telegraphic Communication with, 473.
Southwark Bridge Station, The, 326.
Sprague, Mr., and Mr. Albion T. Snell, 66.
St. John's Colliery, The Electric Pumping Plant at, 2.
Standard Types of Electrical Apparatus, 387.
Standardising Laboratory, A, 267.
Standardising Laboratory at Grenelle, The, 725.
Storage Batteries, Mr. Preece on, 96.
Storage Battery Patent Decision in the States, 643.
Storage Batteries for Street Cars, 65, 124.
Supply Companies and the Electric Lighting Act, 123.
Systems of Scientific Units of Measurement, Mr. F. H. Blakesley on, 447.
Tanning, Electricity applied to, 474, 671.
Technical Education, 36.
Telephone Amalgamation, 556, 642, 697.
Telephone Amalgamation, 725.
Telephone Circuits and High Tension Currents, 184.
Telephone Convention, The Proposed, 556.
Telephone, The, as an Adjunct to the Confessional, 156.
Ten Thousand Volts at the Grosvenor Gallery Station, 1.
Tesla Motor, The, 95.
Third Brush Regulation, 183.
Thomson's, Sir William, Inaugural Address, 239, 295.
Tin-plating by Electricity, 727.
TRANSFORMER PATENTS, THE GAULARD-GIBBS AND THE JABLOCHKOFF, 510.
Transformer, Prof. Elihu Thomson's New, 698.
Trotter, Mr. A. P., Appointment of, as Secretary to the Electrical Section, 641.
UNDERGROUND CONDUITS, 738.
Underground Conduits and Electrical Conductors, 609.
UNDERGROUND WIRES IN NEW YORK, 370.
Underground Wires, Report on, 526.
Unit of Electrical Supply, The Proposed Alteration of, 65.
West Brompton Station, The, 358.
Westinghouse Company, The, and its Technical Officers, 66.

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Foreign Correspondence.

AMERICAN NOTES.

Accumulator Patent Decision, An Important, 632.
Acheson, Mr. E. G., on the "Alternative Path," 377.
American Bell Telephone Company, The, 202, 258, 519, 691.
American Electrical Patents during 1888, 465.
American Gas Light Association, The, Meeting at Toronto, 82.
American Inventions at the Paris Exhibition, 465.
American Street Railway Association Convention, The, 20.
Atlantic City, The Sprague Road at, 439.
Baseball by Telegraph, 53.
Bell Telephone Monopoly, The, Probable Extension of, 519.
Bentley-Knight System, The, 52, 347.
Bishop Cables, 346.
Boston, Electric Light Agitation in, 228.
Boston, Proposed Subway System for, 53.
Burke Cable Relay, The, 576.
"C. and C." Motor Company, the, Important Experiment by, 376, 439, 492.
Carbon Brushes for Motors, 575.
Chicago, Electric Lighthouse at, 258
Chicago Opera House, Wiring of the, 377.
Copper Crisis, The, 633.
Copper Ring, The, 284.
Edison Chemical Meter, The, 258.
Edison Convention at Kansas City, 518.
Edison Dynamos for Marine Work, 690.
Edison Interests, The, Consolidation of, 258, 283, 347.
Edison's Laboratory, 720.
Edison Patents, The, 410, 439, 575, 600.
Edison Plant for 80,000 Lamps at Chicago, 518.
Edison's Talking Daily Paper, 203.
Edison "Up-Town" Stations, The, Opening of, 316.
Electric Light Consolidations, 662.
Electric Railway Activity, 575, 690, 719.
Electric Railway Development in 1888, 377.
Electric Railways, Overhead Wires for, 601.
Electric Sugar Fraud, The, 346.
Electric Welding, 22, 576, 633.
Electrical Subways, The, 52, 116, 171, 203, 575, 690, 719.
Electricity and the Monthly Magazines, 720.
Electricity applied to Mining, Mr. T. W. Sprague on, 53.
Electricity, Death by, 115, 228, 317, 575, 601.
Elevated Railways, The, Daft Electric Locomotive on, 170, 492.
Gas and Electricity, 632.
Geyer Meter, The, 116.
Great War Syndicate, The, 258.
Jacksonville Electricians, The, and the Yellow Fever, 83.
Julien Car, Working of a, 749.
Lightning, Dr. M. G. Parker on, 116.
Los Angeles, The Electric Railway at, 285.
Marine Work, Edison Dynamos for, 690.
Methods of Artificial Illumination, Efficiency of, 601.
Modern Views with respect to Electric Currents, 575.
Montreal, Telephone Rate War at, 83.
Montreal, Utilisation of the Lachine Rapids at, 146.
Municipal Electric Lighting, 632.
National Electric Light Association at Chicago, 518.
New York, Growth of Electric Lighting in, 203.
Niagara, Plans for Utilising the Water-power of, 466.
Omaha, The Electric Railway at, 146.
Overhead Wire Agitation, The, 749.
Patten System of Multiplex Telegraphy, 519.
Phonographic and Telephonic Experiments, 491.
Pillsbury Flour Mills, The, Electric Light at, 518.
Revival of Electric Lighting in England, The, 82.
Roberts' Primary Battery, 284.
Sprague System, The, 21, 146, 439, 547.
Stock Tickers and their Patrons, 229.
Storage Battery Cars, 229.
Storage Battery Decision, Important, 660.
Storage Battery Patents, The, 749.
Telautograph, The, 203.
Telegraph, The American Press and the, 283.
Telegraphers' Mutual Benefit Association, The, 171.
Telephone Companies, The, and the State Legislatures, 601.
Telephone Companies, The, and the Presidential Election, 83.
Telephone Litigation, 52, 114, 228, 492.
Telephone Rates, The Agitation for the Reduction of, 410.
Telephone, The, and the Life-Saving Service, 171.
Thomson Transformer, The New, 719.
Thomson Welding System, The, 576, 633.
Thomson-Houston Electric Company, 633.
Thomson-Houston Electric Railroads, 21, 83, 146.
Tesla Motor, The, 21.
Topeka (Kansas), The Electric Railway at, 83.
Train Lighting by Electricity, 410, 575.
United States Illuminating Company v. The Board of Electrical Control, 317.
Washington, The Electric Railway at, 21.
West Indian Cables, 346.
West Indies, The, and South America, American Enterprise in 146.
West Side Electric Light Company, The, and the Board of Electrical Control, 749.
'Western Electrician," The, on the Combination of Conflicting Interests, 284.
Western Union Company, The, and the Board of Electrical Control, 748.
Western Union Telegraph Company, The, 202, 258, 317, 633.
Westinghouse Electric Company, The, 21, 53, 115, 203, 410, 547.
Weston's, Mr. E., Measuring Instruments, 115.
Woodward Storage Battery, The, 633.

BRUSSELS NOTES.

Brussels Exhibition, The, List of Awards, 53.
Brussels Municipality, The, and the Thomson-Houston Company, 466.
Brussels, The Electric Lighting of, 347, 548.
Central Hotel, The Lighting of, 260.
Electric Signalling Apparatus for Night Watchmen, 260.
"Etoile Belge," The, Enterprise of, 260.
Gare du Nord, The Installation at, 53.
Ghent, An Installation at, 259.
Houillères-Unies, The Electric Light at, 548.
Lalaing Electric Light Mast, The, 467.
Liége, M. Tudor's Proposals at, 467.
Luxembourg, Grand Duchy of, Electrical Enterprise in, 53.
Mourlon Frères, MM., Formation of, into a Company, 260.
Schanschieff Battery, The, in Belgium, 467.
Syndicat, An Electrical, 259.

GERMAN NOTES.

Allgemeine Elektricitäts Gesellschaft, The, 691.
Barmen Central Station, The, 411.
Berlin Central Stations, The, 411.
Bremen Central Station, The, 411.
Darmstadt Central Station, The, 411.
Elberfeld Central Stations, The, 519.
Electric Motors in Germany, The Manufacture of, 691.
Frankfort, Transformer Plant at, 519.
Fritsche and Pischon's New Wheel Armature Dynamo, 519.
Germany, The Past Year in, 411.
Hamburg Central Station, The, 411.
Nuremberg Railway Station, The Installation at, 519.
Prize of 1,000 Marks, A, 519.
Transmission of Power by Alternating Currents, The 411.

PARIS NOTES.

Amiens, Central Station at, 663.
Bechmann, M., and the Illuminated Fountains at the Exhibition, 663.
Bon Marché, The Lighting of, 548.
Boulevards, The Lighting of the, 662.
Champs-de-Mars, The Provisional Installation on the 662.
Conseil Municipal, The Authorisations of, 259, 547.
Gas Companies, The, and the Electric Light, 662.
"Gymnote," The, 259.
Halles Centrales, Lighting of the, 22, 259, 663.
Heroult Process in France, The, 548.
Left Bank of the Seine, The Lighting of, 663.
Palais-Royal Central Station, The, 22, 259, 347.
Popp, M., on Electric Lighting in Paris, 466.
Société des Métaux, The Fall in the Shares of, 547.
Syndicat International des Electriciens, The Tariff of, 22.
Telegraph Lines, The, and the Snowstorms, 466.
Telephones, The Government and the, 663.
Thomson-Houston System in Paris, The, 347.
Vaucluse, the Asylum at, Lighting of, 663.

SCANDINAVIAN NOTES.

Copenhagen Corporation and the Telephone Company, 576.
Copenhagen, The Electric Light at, 23.
Electric Cable Factory, A Swedish, 576.
Electric Light in Diving Operations, The, 172.
Eriksson Microphone, The New, 576.
Helsingborg, The Electric Light at, 172.
Incandescent Lamp Factory, A Large, 412.
Railway Carriages, The Electric Light in, 412.
Stockholm General Telephone Company, The, and the State Telegraphs, 172.
Stockholm, New Central Station at, 22, 412.
Stockholm Telephone Company, The, Statistics of, 412.
Sundsvall, Electric Tramways at, 412.
Sweden, Electric Lighting Progress in, 23.
Sweden, Inland Telegrams in, 576.
Tanning, Electricity applied to, 23.
Telegraph Rates in Sweden, 23.
Vesteras Central Station, The, 172.

VIENNA NOTES.

Crown Prince Rudolf, The, and the Vienna Electrotechnical Society, 467.
Electric Lighting Activity in Austria, 548.
Houses of Parliament, Lighting of the, 172.
Marienbad, Electricity at, 285.
Passion Plays by Electric Light, 285.
Schenken Strasse Station, The, 172, 285.
Telegraphic Development in Austria, 548.
Telephonic Progress in Austria, 172, 601.
Vienna Telephone Company, The, 467, 749.
Werndl, Mr., Death of, 749.

Letters to the Editor.

Albion Gas Engine, The ..... G. T. P., 320.
Alkaline Accumulators ..... Greville, A. E., 350.
Coates, H. J., 350, 413.
Elwell, P. Bedford, 378.
Beaumont, W. Worby, 378.
Alternating Currents ..... Brown, H. P., 55.
Arc Lamps for Amateurs ..... Bouquet, R. P., 750.
Aurora Borealis, The ..... Mordey, W. M., 379.
Bank of England, The Electric Light at the .. Drake and Gorham, 57.
Barnet Electric Light, *Re* ..... Joel (H. F.) and Co., 25.
Bath, The Invasion of, by the House-to-House Company ..... Massingham, H. G., 280, 351.
Winkworth, H. St. John, 319.
"Disinterested Observer, A," 351.
"Marsden," 351.
Battery Transformers and the Vienna Installation ..... Crompton, R. E., 202.
Ben Nevis, Electric Effects on ..... Lodge, Dr. O. J. (with letter from Omond, R. T.), 205.
Berlin Cables, The ..... Sayers, W. B., 692.
Berners-street Mishap, The ..... Higgins, F., 231.
Bleaching, Electric ..... Andreoli, E., 494.
Cable Testing ..... "Megohm," 86.
Bright, Charles, 148.
Central Lighting Stations of France, The..... Ganz és Társa, 602.
Condition of Alloys and Solid Sulphides, The.. Hibbert, W., 149.
Copper, The Standard Conductivity of ..... Higgins, F., 117.
C. J. S., 149.
Davey-Paxman Engine Trials, The ..... Hartnell, Wilson, 548.
Defence, Electrical ..... Zalinski, E. L., 261.
Deflection of an Electro-Magnetic Wave by Motion of the Medium ..... Heaviside, Oliver, 663.
Designing of Continuous-Current Dynamo Machines, The ..... Geipel, W., 549.
Jamieson, Prof. A., 577.
Disclaimer, A ..... Gill (Arthur B.) and Co., 497.
Dr. Lodge's Experiments ..... "Ignoramus," 749.
Durtnall *v.* Shippey ..... Tadd, John, 692.
Edmunds', Mr., Method of Maintaining Constant Current ..... Bate, Douglas C., 379, 412.
Edmunds, H., 349.
Neville, R. H. C., 349.
Bernstein, Alexander, 379.
Smith (John) and Co., 443.
Education of Electrical Engineers, The ..... Day, Gerald, 720.
Effect of Current upon Conductors, The ..... Bartlett, A. T., 440.
Yeaman, Charles H., 468.
Electric Lighting Companies at Kensington and West Brompton..... Erskine, R. S., 495.
Winkworth, H. St. John, 520.
Electric Lighting of Schools ..... Ryder, Thos., 174.
Electrical Theory ..... Fitzgerald, G. F., 24.
Thompson, Silvanus P., 54.
Heaviside, Oliver, 83.
Hutchinson, Cary S., 173.
Lodge, Dr. O. J., 204.
Electro-Calorimetry ..... Eversheld, Sydney, 24.
Electrolysis, Theory of, An Experiment in the, by Prof. Ostwald ..... Lodge, Dr. O. J., 493 (with Ostwald, Prof. W., and Ramsay, Prof.), 691.
Brown, J. 676.
Electro-Magnetic Effect of a Moving Charge .. Heaviside, Oliver, 83, 147.
Electro-Magnetic Waves and the Propagation of Potential..... Heaviside, Oliver, 23.

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Letters to the Editor (*continued*).

Electrometer, Blondlot and Curie's	ATKINSON, LLEWELLYN B., 261. WILBERFORCE, L. R., 207.
"Elements of Electric Lighting"	ATKINSON, PHILIP, 231.
Elmore's Electro-Burnishing Process	ROUX, GASTON, 148, 205. C. J. S., 173.
Enamel as an Insulator	F. H., 520.
Ether, The	GRANVILLE, W. P., 24.
"Ether"	CARTER, E. T., 351. THOMPSON, N. G., 379.
"Ether, Electricity and Ponderable Matter"	ROSS, O. C. D., 380.
Experimental Lightning Conductors	LODGE, Dr. O. J., 646.
Fahrig's Influence Machine	FAHRIG, ERNST, 205.
Feeders, The Use of	HOLMES AND VAUDREY, Messrs., 634.
"First Course of Mechanical Drawing"	HALLIDAY, G., 389.
Flashed Filaments in Lamps	THOMPSON, Prof. S. P., 261.
Fog, Electrical Dissipation of	LODGE, Dr. O. J., 260, 285. BRUCE, ERIC S., 285.
Fritsche Dynamo, The	JEHL AND RUPP, Messrs., 602.
Galway, The Electric Light at	GALWAY ELECTRIC COMPANY, THE, 288
Gaulard, M. Lucien, The Death of	CADIOT, E. H., 147.
Geyer-Bristol Ammeter, The	JOYCE, SAMUEL, Jun., 174.
Glasgow City Hall Lighting	G. T. P., 263.
Globular Lightning	WORDINGHAM, C. H., 56. J. H., 117. MOORSEL, J. VAN, 520. FAHRIG, ERNST, 413. EVERSHED, SYDNEY, 443. COWAN, EDWARD W., 720.
Harrow, The Lighting of	CROMPTON, R. E., 494.
Hempen-Covered Cables	LUGAR, W. R., 468.
Hookham's Electricity Meter	HOOKHAM, GEORGE, 413.
Injunction against the Julien Company, The	DELL, H., 750.
Institution of Electrical Engineers, The	BIDWELL, SHELFORD, 318. PROVINCIAL MEMBER, A, 380.
Kensington Vestry Report, The	ERSKINE, R. S., 495.
Kimberley, The Lighting of	STATTER (J. G.) AND CO., 320.
Lahmeyer's System of Regulation	HOUSMAN, R. H., 750.
Light without Heat	WORTH, A. B., 412.
Lightning Conductors	FORSTER, W. G., 441.
Magnetic Effect, The, of Convection and Displacement Currents	HUTCHINSON, CARY S., 173.
Magnetization of Soft Iron	EVERSHED, SYDNEY, 24.
Magnetism of Steel Needles, The, by Leyden Jar Discharges	LODGE, Dr. O. J., 204.
Mance's Battery Resistance Test	HIPPISLEY, Capt. R. L., 634.
Meters, Electricity	FORREST, JOHN E., 286.
Mirrors for Galvanometers	SMITH, A. B., 721.
Mœnnich Indicator, The	YEAMAN, CHARLES H., 468.
Mutual Action, The, of a Pair of Rational Current Elements	HEAVISIDE, OLIVER, 229.
Periodicity of Earth-Currents, The	BENGOUGH, A. H., 519.
Photographs of Lightning	A. K. C., 721.
Physiological Effects, The, of Alternating Currents	"TELEGRAPHIST," 350. LAWRENCE, H. NEWMAN, 378.
Piezometer, The, for Deep-Sea Temperature Soundings	STALLIBRASS, E., 55.
Piracy, Alleged	SUDWORTH, S., 263, 320. BINSWANGER (G.) AND CO., 288.
"Practical Electrical Measurement"	EVERSHED, SYDNEY, 468.
Primary Batteries for Large Currents	ROSS, O. C. D., 263. THOMPSON, N. G., 286.
Prof. Joseph Henry's Researches	FLEMING, Dr. J. A., 576.
Projector, The Application of the, in the Training of Heavy Guns	MAYOR, ALFRED E., 286.
Red Wire *versus* Black	DRAKE AND GORHAM, Messrs., 379.
Refuse Destructors and the Electric Light	BROOKMAN, F. W., 350.
Regulation of Dynamos, The, by Means of a Third Brush	NICHOLS, EDWARD L., 440.
Rewards for Meritorious Discoveries and Inventions	WAHL, W. H., 57.
Shunts, Electro-Magnetic	PREECE, W. H., 260.
Society of Telegraph Engineers and Electricians, The Council of the	"TELEGRAPHY," 150.
Sprague Motors at Richmond, The, and Mr. Albion T. Snell's Criticism	SPRAGUE, FRANK J., 85. SNELL, ALBION T., 116.
Standards of Light	WILLIAMS, M. WHITLEY, 319.
Storage Battery Patents	COURTENAY, J. IRVING, 692.
Technical Education	PERRY, Prof. JOHN, 263.
Telegraphy without Wires	BRIGHT, CHARLES, 24. SWINTON, A. A. C., 25, 348, 378. HAWES, F. B. O., 56. NEVILE, R. H. C., 56. SMITH, WILLOUGHBY, 56. HIGGINS, F., 57, 378. HEAVISIDE, OLIVER, 412.
Telephone Call Office	"A. S. T. E. AND E.," 24, 57, 117. MUNRO, J., 87. BEGG, F. FAITHFULL, 117, 150.
"Telephone, The," by Preece and Maier	J. M., jun., 352.
Testing Insulation Resistance	JAMIESON, ANDREW, 467. MELHUISH, T. W. W., 520.
Theory of the Arc Lamp, The	HARTNELL, WILSON, 577.
Thomson's, Sir William, Simple Hypothesis	WATSON, H. W., 147.
Traction, Electric	PARKER, T., 204, 262. RECKENZAUN, A., 230, 286. WARD, RADCLIFFE, 262. CAPITO, C., 286.
Tragic Incident, A Small	PALETHORPE, H., 67.
Wiring of Houses, The	PARDOE, GEORGE T., 664.

Scientific Societies, Papers, &c., read before.

American Institute of Electrical Engineers.

Efficiency of Methods of Artificial Illumination, 601.	NICHOLS, Prof. F. L.
Gearing for Electric Railways, Note on, 28.	ROBINSON, ALMON.
Geyer-Bristol Meter, The, for Direct and Alternating Currents, 137 (*see also* 174).	GEYER, Prof. WILLIAM E.
Lightning Arresters and the Photographic Study of Self-Induction, 377.	ACHESON, E. G.
Six Years' Experience with the Edison Chemical Meter, 258.	JENKS, W. J.

Birmingham Philosophical Society.

Loss of Voltaic Energy of Electrolytes, The, during Chemical Union, 626.	GORE, Dr. G.

Boston Electric Club.

Central Station Practice in Germany, 131.	PARSONS, F. J.

British Association (Bath Meeting, 1888).

Conduction, The, of Alloys and Solid Sulphides, 48 (*see also* 149).	GLADSTONE, Dr. J. H., and HIBBERT, W.

British Association (Communications to the Electrolysis Committee).

Ostwald's Experiments on Electrolytic Dissociation, 676.	BROWN, J.
Some Fundamental Points in the Theory of Electrolysis, 459.	ARMSTRONG, Dr.

City and Guilds of London Institute Old Scholars' Association.

Design of Electric Motors, Note on the, 310. *Discussion*, 403.	SNELL, ALBION T.

Electric Telegraph Association of Victoria.

Annual Meeting, 45.	

Elektrotechnische Verein, Berlin.

Transmission of Power by Alternating Currents, The, 411.	RAYMOND, A. DU BOIS.

Franklin Institute.

Electric Welding, 72.	THOMSON, Prof. ELIHU.

Institution of Electrical Engineers. (See also *Society of Telegraph-Engineers and Electricians.*)

Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits, 453, 480.	KENNELLY, A. E.
Disturbances arising from the Use of "Earth" for Electric Lighting Purposes, 618.	PREECE, W. H.
Ether, Electricity, and Ponderable Matter, 303, 331, 362.	THOMSON, Sir W.
Insulation Resistance, The, of Electric Light Installations, 340.	JAMIESON, Prof. A.
Lessons to be learned from Foreign Central Station Lighting, 505, 528, 679, 716.	FORBES, Prof. G.
Lightning, Lightning Conductors, and Lightning Protectors, 731.	LODGE, Dr. O. J.
Underground Conduits and Electrical Conductors, 718, 746. *Meetings.*—Members', 303, 365; Students', 423, 475, 528.	VERITY, JOHN B.

Institution of Engineers and Shipbuilders in Scotland.

Designing of Continuous-Current Dynamo Machines, On the, 487, 515 (*see also* 549, 577).	JAMIESON, Prof

National Electric Light Association of America.

Underground Conduits and Conductors, *Report of Committee on*, 544.	

New York Railway Club.

Electric Train Lighting, 575.	WAITE, Dr. H. R.

North of England Institute of Mining and Mechanical Engineers.

Coal-Cutting Machines, Electrical, 282.	PRESIDENT'S ADDRESS

Philosophical Society of Glasgow.

Wiring of Buildings for Electric Light, The, 619 (*see also* 664). *Meeting*, 699.	ANDREWS, J. D. F.

Physical Society.

Annual General Meeting, 489.	
Clark Cell as a Source of Standard Currents, On the, and on its Application to the Calibration of Sensitive Long Range Galvanometers, 590.	THRELFALL, R., and POLLOCK, A.
Coefficient of Mutual Induction of a Helix and a Coaxial Circle, On the, 75.	JONES, Prof. J. V.
Dark Flash, The, seen in some Lightning Photographs, 677.	WHIPPLE, G. M.
Divergence, The, of Electromotive Forces from Thermo-Chemical Data, 374.	HERROUN, Prof. E. F.
Electrical Measurement, 489, 513.	AYRTON, Prof. W. E., and PERRY, Prof. J.
Existence of an Undulatory Movement accompanying the Electric Spark, On the, 224.	COOK, Dr. ERNEST H.
Lecture Experiment Illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel, 677.	BIDWELL, SHELFORD.
Measurement of High Specific Resistances, The, and the Measurement of the Resistance of Imperfectly Purified Sulphur, 625.	THRELFALL, Prof.
Modification, A, of the Ordinary Method of Determining Electro-Magnetic Capacity, 169.	WAGHORNE, Dr.
Quartz as an Insulator, 678.	BOYS, C. V.
Relation, A, between Magnetisation and Speed in the Dynamo Machine, 374.	THOMPSON, Prof. S. P.
Rotation of the Plane of Polarisation of Light by the Discharge of a Leyden Jar, 564. *Discussion*, 565.	LODGE, Dr. O. J.

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Scientific Societies, Papers, &c., read before (*continued*).

Physical Society—(*continued*).
Standard Resistance Coil, On a Form of, 74. — FLEMING, Dr. J. A.
Suppressed Dimensions of Physical Quantities, The, 108. — RUCKER, Prof. A. W.
Discussion, 109.
Use of Lissajou's Figures for Determining Speed of Rotation, On the, and on the Direct Determination of the Vibration Period of a Reed or Tuning Fork by Means of a Morse Receiver, 589. — JONES, Prof. J. V.

Royal Institution.
Discharge of a Leyden Jar, The, 531. — LODGE, Dr. O. J.
Electrical Stress, 451. — RUCKER, Prof.
Meetings, 3, 127, 728.

Royal Meteorological Society.
Meetings, 69, 699.

Royal Society.
Light, On an Effect of, upon the Magnetisation of Iron, 574. — BIDWELL, SHELFORD.
Magnetisation of Iron, The, at High Temperatures, 679. — HOPKINSON, Dr. J.
Magnetisation, The, of Iron and other Magnetic Metals in Very Strong Fields, 103 — EWING, J. A. and LOW, W.
Meetings, 131, 297, 619, 727.

Royal Society—(*continued*).
Method of Detecting Dissolved Chemical Compounds and their Combining Proportions, 718. — GORE, Dr. G.
Method of Examining Rate of Chemical Change in Aqueous Solutions, 591. — GORE, Dr. G.
Relative Amounts of Voltaic Energy of Dissolved Chemical Compounds, 565. — GORE, Dr. G.
Relative Amounts of Voltaic Energy of Electrolytes, The, 626. — GORE, Dr. G.

Society of Arts.
Arc Lamps and their Mechanism, 534, 568, 596, 627 (*see also* 577). — THOMPSON, Prof. SILVANUS P.
Electric Meters for Central Stations, 371, 393. — FORBES, Prof. GEORGE.
Discussion, 436.
Secondary Batteries, 784. — PREECE, W. H.

Society of Telegraph-Engineers and Electricians. (See also *Institute of Electrical Engineers.*)
Electrical Distribution, On a System of, 80 (*see also* 110). — EDMUNDS, H.
Discussion, 104, 196.
Meetings: Annual, 167, 195; Students', 67.
Ocean Temperatures in Relation to Submarine Cables, 25. — CARPENTER, W. LANT.
Discussion on, 49.

Electric Lighting.

Accident at Deptford, 643, 644.
Accident, Singular, at Chicago, 449.
Accidents with the Electric Light, 125.
Accumulator Patents, Important Legal Decision *re*, in America, 632, 661.
Acheson Cable Protector, The, 747.
Activity, Electric Lighting, 38.
Aids, Electrical, to the Drama, 280.
Alpha Arc Lamp, The, 711.
Amateurs, An Arc Lamp for, 689.
America, the Western States of, The Electric Light in, 519.
American Gas Light Association, The, and the Electric Light, 82.
American Opinion on Electric Lighting in England, 82.
Ammeter for Large Currents, Paterson and Cooper's, 135.
Anglo-American Brush Electric Light Corporation's Business, 98, 450.
Arc Lamp, The Theory of the, 577.

Arc Lamps—
Alpha, 711.
Amateurs, for, 689, 750.
A New, 69.
Breguet, The, 509.
Brockie-Pell, The, 242, 570, 598.
Bürgin, The, 282.
Crompton-Crabb, The, 598.
De Puydt, The, 226, 627.
Fein, The, 490.
Kennedy, The, 571.
Macquaire's Alpha, 711.
Menges, The, 599.
Pieper, The, 73.
Pilsen, The, 599.
See-Saw, or Brockie-Pell, The, 242, 570, 598.
Serrin, The, 570.
Siemens, The, 435.
Thomson-Houston, The, 597.
Thomson-Rice, The, 627.

Arc Lamps and their Mechanism, 500, 534, 568, 577, 596, 627.
Areas of Electric Lighting, The, 99, 476.
Armature, A 46ft., 1.
Army Signalling, Incandescent Lamps for, 424.
Aron Meter, The, 393, 438.
Artificial Illumination, The Efficiency of Methods of, 601.
Ayrton's, Prof., Low-reading Commercial Voltmeter, 474.
Bate Decision, Effect of the, on Electric Lighting in the United States, 425, 439.
Batteries, Secondary, Patent Rights in, 483, 692.
Batteries, Storage, American, 157, 643.
Battery Transformers and the Vienna Installation, 202.
Battery Transformers, M. Paul Hoho on, 211.
Battlefield, The Electric Light on the, 213.
Board of Trade Circular respecting Underground Mains, 399.
Board of Trade Inquiry at Brighton, 686.
Board of Trade Inquiry on the London Electric Lighting Provisional Orders, 609, 630, 641, 647, 683, 703, 709.
Board of Trade, Letter from the, to the Chairman of the London County Council, 585.
Board of Trade, The, and the Electric Lighting Companies, 211, 239, 256, 388, 555.
Boats, Torpedo, The Electric Light on, 241.
Breguet Arc Lamp, The, 509.
Brockie-Pell Arc Lamp, The, 242, 570, 598.
Brooks Underground Cable System, The, 643.
Brussels Exhibition, The Electric Light at the, Report on, 260.
Buildings, The Wiring of, for Electric Light, 619, 664.
Buoys, Electrically-Lighted, 449, 502.
Burgin Arc Lamp, The, 282.
Cabbage Leaves, Electric Lamps from, 159.
Cable Protector, Mr. Acheson's, 747.
Caldwell, Edward, on Dynamo Regulation by means of a Third Brush, 217, 256.
Canada, Electric Light Patents in, 600.
Canada, The Edison Patents in, 214, 575.
Candle-power, Determination of, from the Current, 268.
Casings, Wire, 98, 450.
Cassels, W. R., on Electric Lighting in the City of La Plata, South America, 273.

Central Lighting Stations—
Amiens, 663.
Barmen, 411.
Berlin, 411, 679.
Bradford, 126.
Bremen, 411.
Brighton, 265.
Brompton, 98, 358, 367, 396.
Brussels, 53, 260, 347, 466, 548.
Chelsea, 185.
Darmstadt, 411.
Deptford, 450.
Derby, 186, 243.
Dieulefit and Valréas (France), 345.
Elberfeld, 519.
France, 259, 547, 602.
Galway, 475.
Germany, 131, 411, 537.
Grosvenor Gallery, 1, 10, 71.
Hamburg, 411.
Ipswich, 157.
London and Provinces, 255.
Milan, 681.
Milianah (Algeria), 700.
Moscow, 328.
New York, 316.
Pall Mall, 157.
Paris, 22, 259, 310, 347, 466, 643, 663.
Provinces and London, 255.
Pordenone (Italy), 185.
Rome, 716.
Sheffield, 184.
Southwark Bridge, 326.
Stockholm, 412.
Valencia (Spain), 126.
Vienna, 172, 285, 467, 548.
Whitehall, 152.

Chain Cables, Testing, by the Electric Light, 476.
Charlesworth and Co., Messrs., and the Electric Light, 125.
Chelmsford, A New Industry at, 159.
Chemical Meter, Edison's, Six Years' Experience with, 258.
Chenowith Conduit Core, The, 715.
Chicago, Singular Accident at, 449.
Christmas Festivities and the Electric Light, 271.
Church Lighting in London, 185, 557.
Clutch, Common and Joel's, 598.
Clutch, Lever's, 571.
Clutch, Rogers's, 572.
Clutch, Roller, Newton's, 572.
Clutch, Siemens', 599.
Clutch, Slater and Watson's, 571.
Collieries, The Electric Light in, 2-4.
Combination Kerb and Gutter Circuit, 716.
Combination of Electric Light Companies in America, 410, 662.
Combination, Suggested, of the Edison Interests, 258, 283, 347.
Commissioners of Sewers, Report of the Streets Committee of the, on the Lighting of the City of London, 413.
Common and Joel's Clutch-Wheel, 598.
Commutators, The Wearing of, 68.
Compensator, Line Pressure, Westinghouse, 19.
Competition, Electric Meter, in Paris, 298, 328, 558.
Condensers, Distribution of Continuous Currents by Means of, 672, 676.
Conductors, The Effects of Current upon, 440, 468.
Conduit Explosions in New York, 675.
Conduits, Opposition to, in America, 171, 203, 317.
Conduits, Underground, and Electrical Conductors, 541, 713.
Cone, Split, Slater and Watson's, 571.
Conflict of the Systems, The, in the United States, 296.
Constant Current Regulation by Means of Steam Pressure, 422.
Continuous-Current Dynamos, Messrs. Ganz & Co.'s, 529.
Continuous-Current Dynamo Machines, The Designing of, 487, 515, 549, 577.
Contract, A Singular, 725.
Converter, The Zipernowsky, 717.
Copper Wire, Deterioration of, by Electric Currents, 357.
Cost of the Electric Light at the Manchester Jubilee Exhibition, 3.
Cost, The, of Electric Lighting, 3, 68, 228, 268.
Counter, An Electricity, 270.
Crompton-Crabb Arc Lamp, The, 598.
Deptford, Accident at, 643, 644.
De Puydt Arc Lamp, The, 226, 627.
Designing, The, of Continuous-Current Dynamo Machines, 487, 515, 549, 577.
Destructors, Refuse, and the Electric Light, 350.
Distribution, Electrical, M. Popp's Scheme of, 556.
Distribution, Electrical, Mr. Edmunds's System of, 80, 95, 104, 110, 196, 319, 349, 379, 412, 443.
Distribution of Continuous Currents by Means of Condensers, 676.
Distributor, The Edmunds, 110.
Disturbances arising from the use of "Earth" for Electric Lighting Purposes, 618.
Diving Operations, The Electric Light in, 172.
Dolbrava, Dr. Stephen, on The Distribution of Continuous Electric Currents by means of Condensers, 676.
Doulton Conduit, The, 714.
Drama, Electrical Aids to the, 280.
Dynamo Machine, Relation between Magnetisation and Speed in the, 374.
Dynamo Regulation by means of a Third Brush, 217, 256, 440.

Dynamos—
Lowrie-Parker, The, 367.
Rankin-Kennedy, The, 516.
Fritsche-Pischon Wheel, The, 519, 602, 655.
Ganz and Co.'s Continuous-Current, 529.
Woodhouse and Rawson, The, 118.
Zipernowsky Alternator, The, 717.

Dynamos, French, 698.
Dynamos, The Regulation of, 4.
"Earth," Disturbances arising from the Use of, for Electric Lighting Purposes, 618.
"Economic Value, The, of Electric Light and Power," 632.
Economics of Planning and Constructing Electric Light and Power Stations, 511, 572, 624, 712.
Edison Illuminating Companies, Association of, Session of the, 493, 518.
Edison Patents, The, in Canada, 214, 410, 439, 575, 600.
Edison-Swan Case, The Judgment in the, 447.
Edison-Swan Company, The, and the Sunbeam Lamp, 643.
Edison Three-Wire Meter, The, 373.
Edison's New Method of Potential Regulation, 581.
Electricity Supply Companies, The, and their Masters, 326.

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Electric Lighting (*continued*).

Electric Light, The, at Home—
Allendale, 37.
Ballymena, 612.
Barnet, 25, 38, 126, 156, 157, 241, 328, 424, 451, 477, 585, 643, 728.
Bath, 214, 270, 280, 288, 319, 351, 475.
Bedford, 124, 241.
Birmingham, 5, 37, 39, 271, 328, 391.
Bishop's Stortford, 241.
Bournemouth, 37.
Bradford, 126, 213.
Brighton, 310, 390, 644, 686.
Bristol, 37.
Brixlegg, 285.
Buckingham Palace, 98.
Cannock Chase, 214.
Cardiff, 297.
Chelmsford, 558, 584, 727.
Cheltenham, 503, 527, 529.
Chester, 558, 674.
Chiswick, 269.
Colchester, 611.
Cowpen, 99, 124, 156, 157, 243.
Derby, 186, 243, 268, 269.
Dockyards, The, 99, 241, 329.
Dorchester, 558.
Dublin, 156, 157, 360.
Dudley, 527.
Dundee, 241, 329.
Eastbourne, 3, 173.
Edinburgh, 269.
Exeter, 423, 557.
Folkestone, 241, 700, 727.
Fort Augustus, 673, 701.
Forth Bridge, 586.
Galway, 288, 475, 583.
Gillingham, 3.
Glasgow, 98, 263.
Halifax, 424, 528, 612.
Harleston, 643.
Harrow, 473, 494.
Hastings, 5.
Horsington, 241.
Ilfracombe, 213.
Ipswich, 39, 123, 157, 186, 359, 449, 644.
Jedburgh, 3.
Lake District, 475.
Lambeth, 360, 389.
Leamington, 157, 186, 296, 298, 450.
Liverpool, 328, 359, 423, 453, 612.
Lurgan, 643.
London—
Bank of England, 57, 558.
Battersea, 727.
Brompton, 98, 358, 367, 396, 495.
City of London, 3, 125, 186, 242, 270, 328, 361, 413, 449, 473, 699.
Chelsea, 95, 123, 127, 185, 214, 328, 423, 557, 634.
Clerkenwell, 528.
Fulham, 674.
Greenwich, 503.
Holborn, 125, 269, 328, 475.
Inner Temple, 186, 699, 727.
Kensington, 37, 69, 151, 187, 359, 414, 495, 520.
Newington, 98, 328, 727.
Paddington, 67, 183, 189, 641, 658, 701.
Pall Mall, 157, 187.
Rotherhithe, 185, 475.
St. George's, Hanover Square, 185, 215, 327, 361, 502, 699.
St. George the Martyr, 360, 449.
St. James's Parish, 4, 98, 186, 214, 297, 329, 389, 727.
St. Luke's, 269, 389.
St. Margaret's and St. John's, 98, 186, 298, 528.
St. Martin's-in-the-Fields, 98, 186, 359, 423, 475, 527, 643.
St. Pancras, 157.
Southwark, 124, 185, 359, 475, 501, 527, 584.
Strand District, 185, 299, 423, 476, 699.
Teddington, 557.
University College, London, 643.
Victoria Embankment, 186.
Woolwich Arsenal, 213.
Malvern Link, 269.
Manchester, 3, 327.
Morecambe, 97, 298, 476.
Newcastle, 359, 475, 527, 611.
Northampton, 673.
Norwich, 477, 612, 699.
Nottingham, 389, 503, 584.
Okehampton, 185, 502.
Oldham, 97.
Portsmouth, 241, 329.
Plymouth, 699.
Reading, 328, 584.
Scarborough, 643.
Sheffield, 69, 184, 528.
Southampton, 611.
St. Alban's, 558.
St. Catherine's Lighthouse, Isle of Wight, 390.
Strathearn, 529.
Sunderland, 37.
Swansea, 68, 297.
Taunton, 584.
Wakefield, 477.
Wath-on-Dearne, South Yorkshire, 37.
Weybridge, 675.
Windsor Castle, 527.
Wolverhampton, 361, 389.
Worcester, 611.

Electric Light, The, Abroad—
Amiens, 663.
Augsburg, 3.
Barmen, 411.

Electric Light, The, Abroad (*continued*)—
Berlin, 5, 213, 411, 679, 692.
Boston, Mass., 53, 228.
Brazil, 389.
Bremen, 411, 502.
Brisbane, 390.
Brussels, 45, 53, 259, 466, 548.
Chicago, 258, 377, 518.
Copenhagen, 3, 22, 412.
Darmstadt, 411.
Dieulefit and Va'réas (France), 345.
Elberfeld, 519.
Florida, 83.
Frankfort-on-the-Main, 213, 411, 519.
Galatz, 673.
Ghent, 259.
Gilly (Belgium), 548.
Hamburg, 411.
Honolulu, 214.
Hoosac Tunnel (Mass., U.S.A.), 527.
Houillères-Unies, 548.
Johannesberg, 699.
Karlsbad, 548.
Kimberley, 271, 320.
La Plata, City of, 273.
Liége, 467.
Lübeck, 411.
Luxembourg, Grand Duchy of, 53.
Madrid, 475, 674.
Marienbad (Bohemia), 285.
Marienthal, 411.
Meaux (France), 449.
Meiringen (Switzerland), 327
Metz, 327.
Mexico, 502.
Milan, 502, 681.
Millanah (Algeria), 700.
Montreal, 297.
Moscow, 328.
Mysore Palace, 699.
Newfoundland, 527.
New York, 203, 316, 389.
New Zealand, 389.
Norway, 172.
Nuremberg, 519.
Paris, 22, 213, 259, 310, 347, 466, 476, 548, 556, 643, 662.
Paris Exhibition, 22, 548, 663.
Pekin, 475.
Pordenone (Italy), 185.
Rome, 285, 327, 716.
St. Ouen, 213.
Saragossa, 643.
Sofia, 297, 449.
Spain, 270, 643.
Stockholm, 412.
Suakin (*with plan*), 82, 185.
Suez Canal, 125, 673.
Sweden, 22, 172, 412.
Syra, 125.
Toulouse, 4.
Valentia, 126.
Vaucluse, 663.
Vienna, 172, 185, 214, 262, 285, 428, 467, 548.
West Indies, 146.

Elwell-Parker, Messrs., New Works of, at Wolverhampton, 361.
Equaliser, Foucault's, 536.
Equaliser, Houdin's, 536.
Faure's New Secondary Battery, 117.
Feeders, The Use of, 581, 634.
Fein Arc Lamp, The, 490.
Ferranti Meter, The, 71, 374
Ferry Boats, Woolwich, The Electric Light on the, 124.
Festivities, Christmas, and the Electric Light, 271.
Filaments, Flashed, in Lamps, 261, 268.
Forbes, Prof., on Electricity Meters, 325, 371, 393.
Forbes, Prof. G., Report by, on the Electric Lighting of Paddington, 641, 658.
Forbes Windmill Meter, The, 395, 438.
Foreign Central Station Lighting, Lessons to be Learned from, 500, 505, 528, 581, 679, 716.
Foucault's Equaliser, 536.
French Dynamos, 698.
Fritsche and Pischon's Wheel Dynamo, 519, 602, 655.
Fyfe-Main Company, The, 2.
Gas and Electricity, a Method of Reconciling, 124.
Gas Companies and the Electric Light, 632, 645, 690.
Gas Mains as Electrical Conduits, 360.
Gas *v.* Electricity, 124, 451, 501, 632, 645.
Gerlach, Dr., on an Arc Lamp for Amateurs, 689.
Germany, Central Station Practice in, 131.
Geyer-Bristol Meter, The, 116, 124, 137, 174.
Gordon Conduit, The, 716.
Guns, Heavy, The Application of the Projector in the Training of, 286.
Hallwachs, W., on the Electrification of Metallic Plates by Illumination with the Electric Light, 409.
High-Tension Currents, An Experiment with, 184.
Hoho, M. Paul, on Battery Transformers, 211.
Holmes's Feed, 597.
Homes and Workshops, Electricity in Our, 242.
Hookham Electricity Meter, The, 357, 369, 413.
Hopkinson Three-Wire Patent, Purchase of the, 725.
Hospital Lighting, 673.
Houdin's Equaliser, 536.
Houses of Parliament, The Electric Light in the, 187, 297, 450, 558.
Houses, Private, The Electric Light in, 38.
Hurlbut Conduit, The, 714.
Improvements in Secondary Battery Plates, 38.
Incandescent Lamp, Long Life of an, 242.
Incandescent Lamp for Optical Purposes, 689.
Incandescent Lamps: Candle-Power and Current, 282, 358.
Incandescent Lamps, Portable, Intercalating Apparatus for, 549.
Indian Government, The, and Electric Lighting, 476.
Incident, Tragic, A Small, 67.
Indica or, Mœnnich, 438, 468.
Inquiry, Board of Trade, at Brighton, 686.
Inquiry, Board of Trade, on the London Electric Lighting Provisional Orders, 609, 630, 641, 647, 683, 703, 739.
Insulation Resistance of Installations, The, 387, 421.
Insulation Resistance, Testing, 467, 520.
Insulation Resistance, The, of Electric Light Installations, 349.
Intercalating Apparatus for Portable Incandescent Lamps, 549.
Internal Resistance, A 10,000-Volt Transformer for Testing, 281.
Irish Conduit, The, 716.
Isolated Plants *v.* Central Station Service, 474.
Is the Electric Light Injurious to the Eyes? 270.
Joel's Scissors Joint, 571.
Johnson Iron Conduit, The, 715.
Junction Box by Siemens and Halske, 717.
Junior Engineering Society, Visit of the, to Deptford, 450.
Kennedy Arc Lamp, The, 571.
Kensington Court (Draft) License, 1, 13, 36.
Lahmeyer Potential Regulator, The, 581.
Lake Conduit, The, 714.
Lalaing Electric Light Mast, The, 467.
Lamplight, A Song after, 701.
Lamps, Flashed Filaments in, 261.
Land Warfare, The Electric Light in, 187.
Lead-Covered Cables, 555, 583, 692, 697.
Lessons to be Learned from Foreign Central Station Lighting, 505, 528, 679.
Lever's Clutch, 571.
License (Draft), Kensington Court, 1, 13.
Lighthouse Illuminants, 674.
Lighthouses, The Electric Light in, 258, 559.
Light without Heat, 412.
Light without Heat, Prof. Brackett on, 357.
Locomotives, Electric Lamps for, 185.
London Electric Lighting Areas, Stanford's Map of the, 476.
London Electric Supply Corporation's Central Lighting Station, 1, 10, 71.
Long Life of an Incandescent Lamp, 242.
Lowrie-Hall Meter, The, 394.
Lowrie-Hall Potential Regulator, 397.
Lowrie-Parker Dynamo, The, 367.
Mackie's, Mr., Report on the Paddington Electric Lighting Scheme, 183, 189.
Manchester Jubilee Exhibition, Cost of the Electric Light at the, 3.
Map of the London Electric Lighting Areas, Stanford's, 476.
Maquaire's Alpha Arc Lamp, 711.
Mavor, Alfred E., on Electric Lighting at the Erection of the Forth Bridge, 586.
Memorandum by the Board of Trade on the Lighting of London, 256.
Menges Arc Lamp, The, 599.
Mercury Switchboard, 717.
Metallic Plates, The Electrification of, by Illumination with the Electric Light, 409.
Meter, Electric, Competition in Paris, 298, 328, 558.

Meters, Electric—
Aron, The, 393, 438.
Central Stations, for, 371, 393.
Edison Chemical, The, 258.
Edison Three-Wire, The, 373.
Ferranti, The, 71, 374.
Forbes's Windmill, The, 395.
Geyer-Bristol, The, 116, 124, 137, 174.
Hookham, The, 357, 369, 413.
Lowrie-Hall, The, 394.
Schallenberger, The, 295.

Metropolitan Board of Works, The, and the Electric Light, 359.
Metropolitan Electric Supply Company, The, 36, 557.
Mining, Electricity and, 4, 53.
Mishap in Berners-street, 229.
Mœnnich Indicator, The, 438, 468.
Montreal, Utilisation of the Lachine Rapids at, 83.
Motor Competition, The Society of Arts, 424, 527, 548, 584.
Müller and Lahmeyer's Distributing System, 703.
Municipal Review, The, and Electric Light Contractors 240.
National Electric Light Association Convention at Chicago, 440, 518, 544.
Naval Purposes, Electric Signalling for, 240.
Navy, Royal, The Electric Light in the, 186.
Newton's Roller Clutch, 572.
New Zealand, Progress in, 68, 242.
Office Lighting, 587.
Optical Purposes, An Incandescent Lamp for, 689.
Overhead Wires, The Government on, 67, 644.
Overhead Wires, The London County Council and, 674.
Overhead Wires *v.* Underground Wires, 116, 211, 325, 529.
Paris Exhibition, Arrangement and Cost of the Electric Light at, 22.
Parliamentary Notices under the Electric Lighting Acts, 131, 175.
Parliament, Houses of, the Electric Light in the, 187, 297, 450, 558.
Parliamentary Intelligence, 221.
Patents, Electric Lighting, in America, 203, 326, 425, 439.
Paterson and Cooper's Ammeter for Large Currents, 135.
Pieper Arc Lamp, The, 73.
Pilsen Arc Lamp, The, 599.
Popp Scheme of Electrical Distribution, The, 556.
Potential Regulation, Edison's New Method of, 581.

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Electric Lighting (*continued*).

Potential Regulator, Lowrie-Hall, 397.
Potential Regulator, The Lahmeyer, 581.
Preece, Mr., on Secondary Batteries, 96, 726, 734.
Primary Batteries, Experiments with, 284.
Primary Batteries for Lighting Purposes, 263, 286.
Private Houses, The Electric Light in, 38.
Progress of the Electric Light in New York, 203.
Progress in New Zealand, 242.
Projector, The Application of the, in the Training of Heavy Guns 286.
Projectors in Fortifications at Metz, 327.
Rankin-Kennedy Short-Wind Dynamo, The, 516.

Recent Installations –
Ballymena, 612.
Brussels, 347.
Chelsea, 643.
Copenhagen, Brewery at, 3.
Dieulefit and Valréas (France), 345.
Dolhain (Belgium), 259.
Durango (Spain), 643.
Fort Augustus, 701.
Garrick Theatre, 701.
Ghent, 259.
Gilly (Belgium), 548.
Jedburgh, Woollen Mills at, 3.
Johannesberg, 699.
Milianah (Algeria), 700.
Moscow, 328.
Northampton, 673.
Paris, 259, 347, 643.
Private Houses, 38.
Roubaix, 423.
Wath-on-Dearne, 37.

Red Wire *versus* Black, 379.
Refuse Destructors and the Electric Light, 350.
Regulator, House, Westinghouse, 19.
Relation between Magnetisation and Speed in the Dynamo Machine, 374.
Report on the Insulation Measurements made on the Electric Lighting Installation at the New Court Theatre, Vienna, 428.
Report of the Special Committee of the Kensington Vestry, 414, 495.
Report of the Streets Committee of the Commissioners of Sewers on the Lighting of the City of London, 413.
Resistance, The Insulation, of Electric Light Installations, 340.
Rogers's Clutch, 572.
Royal Navy, The Electric Light in the, 186.
Salmon Fishing, Illegal, and the Electric Light, 67.
Schallenberger Meter, The, 395.
Schanschieff Battery, The, in Belgium, 467,
Schools, The Electric Lighting of, 174.
Search Lights and Torpedo Boats, 675.
Secondary Batteries, Patent Rights in, 483, 692, 749.
Secondary Batteries, The Electrolyte used in, 726.
Secondary Battery, Faure's New, 117.
Secondary Battery Plates, Improvements in, 38.
Serrin Arc Lamp, The, 570.
Ship Lighting, 613, 644, 673.
Siemens Arc Lamp, The, 435.
Siemens' Clutch-Wheel, 599.
Signalling, Army, Incandescent Lamps for, 424.
Signalling, Electric, for Naval Purposes, 240.
Six Years' Experience with Edison's Chemical Meter, 258.
Slater and Watson's Clutch, 571.
Slater and Watson's Split Cone, 571.
Snell, Albion T., on Tangent Function Multipliers to be used with the Kapp Formulæ in the Design of Dynamos and Motors, 337.
Society of Arts Motor Competition, 424, 527, 548, 584.
Song after Lamplight, A, 701.
Spanish Theatres, Electric Light Failures in, 270.
Sports, The Electric Light and, 147.
Standards of Light, 267, 319.
"Star," An Electric, 423.
Storage Batteries, American, 157.
Subways, Electrical, 52, 116, 171, 203, 575, 690, 719.
Subways, Electrical, in America, 52, 53, 575.
Suez Canal, Passage of, by Night, 125, 673.
Supply Companies and the Electric Lighting Act, 123.
Swinburne Incandescent Lamp, 159.
Switch-Board Arrangement, Westinghouse Station, 18.
Switchboard, Mercury, 717.
Switch, or Intercalating Apparatus, for Portable Incandescent Lamps, 549.
Syndicate, An Electrical, 259.
Systems of Scientific Units of Measurement, Mr. Blakesley on, 447.
Tangent Function Multipliers to be used with the Kapp Formulæ in the Design of Dynamos and Motors, 337.
Tenders Wanted, 449, 611, 673, 727.
Testing Chain Cables by the Electric Light, 476.
Testing Insulation Resistance, 467, 520.
Theatres, The Electric Light in, 50, 270, 297, 377, 428, 475, 701.
Thomson-Houston Arc Lamp, The, 597.
Thomson-Houston Electric Co., Progress of the, 361.
Thomson-Rice Arc Lamp, The, 627.
Torpedo Boats and Search Lights, 675.
Tragic Incident, A Small, 67.
Trains, The Electric Light in, 157, 213, 410, 412, 502, 575.
Transformer, A 10,000-Volt, for Testing Internal Resistance, 281.
Transformer, Prof. Elihu Thomson's New, 698, 719.
Transformers, Battery, and the Vienna Installation, 262.
Underground Cable System, The Brooks, 643.
Underground Conduits and Electrical Conductors, 526, 544, 609, 713.
Underground Mains, Board of Trade Circular respecting, 399.
United States, Electric Lighting in the, Effect of the Bate Decision on, 425, 439.
Unit of Electrical Supply, Proposed Alteration of, 65.
Verity Conduit, The, 714.
Vision, The Electric Light and, 270.
Voltmeter, A New, 116.
Voltmeter, Ayrton and Perry's, for Electric Welder, 514.
Voltmeter, Low-reading Commercial, Prof. Ayrton's, 474.
Voltmeter, Standard, Westinghouse, 19.
Vyle, Mr. S., Lecture by, 241.
Waltenhofen, Dr. A. von, Report on the Insulation Measurements made on the Electric Lighting Installation at the New Court Theatre, Vienna, 428.
Warfare, Land, The Electric Light in, 187.
Waterhouse System, The, 67, 115.
Wearing of Commutators, The, 68.
Westinghouse Company, The, and its Technical Officers, 66.
Westinghouse Converter, The, 451.
Westinghouse Electric Company, Progress of the, 21, 53, 115, 129, 162, 203, 410, 547.
Westinghouse Station Switch-Board Arrangement, 18.
Westinghouse System, Large Contract for the, in England, 53.
Weston's Mr., Measuring Instruments, 115.
West Side Electric Light Company, The, and the Board of Electrical Control, 749.
Windmill Meter, The Forbes, 395, 438.
Wire Casings, Useful Improvement in, 450.
Wire, Red *versus* Black, 379.
Wiring of Buildings for Electric Light, The, 619, 664.
Wood Casings for Electric Wires, 98, 450.
Woodhouse and Rawson Dynamo, The, 118.
Woodward Storage Battery, The, 633.
Woolwich Ferry Boats, The Electric Light on the, 124.
Workshops and Homes, Electricity in Our, 242.
Wright, Alex. P., on The Economics of Planning and Constructing Electric Light and Power Stations, 511 572, 624.
Yachts, Royal, Electric Lighting on board the, 644.
Zipernowsky Alternator, The, 717.
Zipernowsky Converter, The, 717.
Zopke Competition, The, 519.

Electric Traction and Transmission of Energy.

Académie des Sciences, The, and Electric Transmission of Power, 241.
Aeronautic Experiments, Light Motors for, 298.
Alkaline Accumulators and the "Gymnote" Submarine Torpedo Boat, 302.
Alternating Currents, The Transmission of Power by, 411.
America, Electric Railways in, 284, 317, 347, 377, 439, 547, 575, 690, 719.
American Street Railway Association Convention, 20.
Ballarat East, Electric Tramway at, 215.
Bentley-Knight Street Railway, The, in New York, 52, 347.
Bessbrook Electric Tramway, The Traffic on the, 389.
Birmingham, Electric Traction in, 51.
Blackpool Tramway, The, 156.
Boat, Submarine, M. Zédé's, 259, 302.
Boxmoor and Hemel Hempstead, Electric Tramway between, 673.
Brussels, Electric Traction at, 557.
Building Operation and Electricity, 673.
Cable System, The, *v.* Electric Power, 172.
Carbon Brushes for Motors, 575.
C. and C. Motor Company's New Factory in New York, The, 376, 439, 492.
City of London and Southwark Subway, Electric Traction on the, 358, 362, 501.
Coal-cutting Machines, Electrical, 282.
Contract for an Electric Launch, 185.
Corn, Threshing, by Electricity, 213.
Crane, An Electric, 103.
Daft Electric Locomotive, The, 170, 204, 492.
Design of Electric Motors, The, 310, 403.
Detroit Storage Battery, The, for Traction Purposes, 633.
Dog Carts and Launches, Electric, Immisch's, 3.
Dundee, Electric Transmission of Power at, 241.
Dynamos for Marine Work, 690.
"Economic Value, The, of Electric Light and Power," 632.
Economics of Planning and Constructing Electric Light and Power Stations, 511, 572, 624, 712.
Electric Power *v.* the Cable System, 172.
Elieson Company, The, 727.
Elieson Sale, The, 613.
Elwell, P. B., on Alkaline Accumulators and the Gymnote Submarine Torpedo Boat, 302.
France, Electric Traction in, 611.
Frankland's Storage Battery for Traction Purposes, 204.
Ganz Alternate-Current Motor, The, 671.
Gearing for Electric Railways, 28.
Geelong, Electric Tramway at, 4.
Germany, Use of Electric Motors in, 691.
Gosport, Electric Tramway at, 3.
Gravesend Electric Tramway: Series System, 526, 541.
Hague, The, Electric Tramway at the, 475.
Haulage, Underground, Electricity and, 99.
Hemel Hempstead and Boxmoor, Electric Tramway between, 673.
Héroult Process in France, The, 548.
Horsington, Experiments at, 241.
India, Proposed Electric Railway in, 501.
Industries Motor Competition, The, 359.
Julien Car, Trial of the, at Birmingham, 51.
Julien Car, Working of a, 749.
Kreb's Electric Motors, 259, 302.
Launches and Dog Carts, Electric, Immisch's, 3.
Launches, Electric, 185, 213.
Liverpool, Electric Traction at, 359, 674.
Locomotive, Electric, The Daft, 170, 204, 492.
London Central Subway Railway, The Proposed, 242, 296, 359, 477, 527.
Los Angeles, Electric Railway at, 285.
Madras, Electric Traction in, 269.
Mandalay, Electric Traction at, 327.
Metropolitan Railway, Proposed Electric Traction on the, 360, 527.
Mines, Electricity in, 2, 4, 53, 214, 298, 360, 390, 449, 644.
Montreal, Utilisation of the Lachine Rapids at, 146.
Morecambe, Electric Traction at, 327.
Motor, Alternate-Current, The Ganz, 671.
Motor Competition, The *Industries*, 359.
Motor, The Tesla, 18, 21, 95, 480.
Motor Truck, Sprague, for Street Cars, 435.
Motors, Electric, Kreb's, 259, 302.
Motors, Electric, The Design of, 296, 310, 403.
Motors, Electric, Use of, in America, 376, 518.
Motors, Electric, Use of, in Germany, 691.
Motors, Light, for Aeronautic Experiments, 298.
Naples, Electric Tramway at, 475.
New York, The Bentley-Knight Street Railway in, 52.
Niagara, Plans for Utilising the Water-Power of, 466.
Norway, Utilisation of the Force of a Waterfall in, 699.
Omnibus, Electrical, The Ward, 124, 358, 423, 611, 644.
Overhead Wires for Electric Traction, 601.
Paris Exhibition Tramway, The, 339.
Paris, Mr., on Electricity in our Homes and Workshops, 242.
Planning and Constructing Electric Light and Power Stations, Economics of, 511, 572, 624.
Power, Electric Transmission of, 68.
Power Station near Piccadilly, A, 725.
Printing by Electricity, 584.
Problem, An Electric Railway, 729.
Reckenzaun's Storage Batteries for Traction Purposes 168, 204, 229, 230, 262, 286.
Reckenzaun's Tramcars, 157, 165.
Rheinfelden, A Power Station at, 674.
Ryde Pier Electric Railway, 436.
Schlesinger Street Railway System, 146.
Series System, The, on the Gravesend Electric Tramway, 526, 541.
Sewage Purification, Electrolytic Method of, Mr. Webster's, 588.
Snell, Albion T, on Tangent Function Multipliers to be Used with the Kapp Formulæ in the Design of Dynamos and Motors, 337.
South London Tramways Company, The, and Electric Traction, 449.
Southwark and Deptford Tramways Company, The, and Electric Traction, 477.
Sprague Motor Truck for Street Cars, 435.
Sprague Motors, Mr. A. T. Snell's Criticism on the, 66, 84, 116.
Sprague Street Railway System, The, 21, 146, 439, 547.
St. John's Colliery, The Electric Pumping Plant at, 2.

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Electric Traction and Transmission of Energy (*continued*).

Storage Batteries for Traction Purposes, 65, 124, 168, 204, 229, 230, 262, 286.
Strike of Tramway Men in New York, 439.
Submarine Boat, M. Zédé's, 259, 302.
Sweden, Electrical Tramways in, 412.
Tanning, Electricity applied to, 23, 474, 671.
Telpherage, The Patent Rights in connection with, 450.
Tesla Motor, The, 18, 21, 95, 480.
Thomson Electric Welding System, 22, 72, 576, 633.
Thomson-Houston Street Railways System, The, 21, 83, 146, 502.
Threshing Corn by Electricity, 213.
Tin-Plating by Electricity, 727.
Topeka, Kansas, Thomson-Houston Street Railway at, 83.
Tramcars, Reckenzaun's, 157, 168.
Tramway Companies and Electric Traction, 612.
Tramway, The Paris Exhibition, 339.
Transfer Table, Electric, at Altoona, Pa., 674.
Trees, Felling, Electric Motors for, 390.
Underground Haulage, Electricity and, 99.
Van Depoele System of Electric Railway, The, 660.
Vevey-Montreux-Chillon Electric Tramway, The, 449.
Webster's, Mr., Electrolytic Method of Sewage Purification, 588.
Welding, Electric, The Thomson System of, 22, 72, 576, 633.
Ward Electrical Omnibus, The, 423, 611, 644.
Washington, The Thomson-Houston Street Railway at, 21.
Waterfall in Norway, Utilisation of the Force of a, 699.
Water Power, Utilisation of, 146.
Weissembach (Austria), Electric Transmission of Power at, 68.
Wright, Alex. P., on the Economics of Planning and Constructing Electric Light and Power Stations, 511, 572, 624.

Telegraphs.

Africa, South, Cable Extension to, 82 (*with map*), 473, 476, 573, 674, 726.
Africa, West, Cable Extension in, 327, 476, 674.
Anglo-Belgian Telegraphs, The, 297, 559.
Anglo-German Telegraphs, 425.
Argentine Republic, The, and the Telegraph, 127, 213.
Australia and Java, New Triplicate Cable between, 476, 611.
Austria, Telegraphic Charges to, 584.
Baseball by Telegraph, 53.
Battle at Suakim, The, 185.
Baudot Telegraph, The, 269.
Bermuda, Telegraphic Communication with, 583, 675.
Bishop Submarine Cable, The, 346.
Brazil, A Submarine Cable Concession in, 97.
Burke Relay, The, 576.
Cable Testing, 86, 148.
Cablegrams, The Coding of, 582.
Cables Interrupted, 3, 185, 389, 527.
Cables Repaired, 37, 241, 359, 385, 449.
Calais-Fredericia Cable, The, 185.
Celebrities, Cable, Portraits of, 583.
China and Tonkin, Telegraph Line between, 673.
Chinese-Russian Telegraph, 345.
Coast Communication, Electrical, 422, 643, 673.
Compact Morse Writing, Siemens' Recording Apparatus for, 505.
Company Amalgamation in the United States, 728.
Conference, Pacific Cable, 89.
Continent, Telegraphy to the, 157, 214.
Continental Cables, The, 184, 425, 448, 501, 525, 559, 582, 611, 613, 642, 643.
Cuban-Spanish Cable, Proposed, 584.
Earth Currents, Periodicity of, 519.
Earth, Imperfect, Certain Phenomena connected with, in Telegraph Circuits, 453, 480.
Edinburgh Association of Science and Art, Lecture before, 242.
Edinburgh, Telegraphy in, 449.
Enterprise, Telegraphic, 53.
Experimental Lightning Conductors at Telegraph Stations Abroad, 2, 641, 646.
Exports of Telegraphic Wires, &c., 105, 158, 270, 423, 528, 645.
Extensions, Submarine Telegraph, 215, 327.
Fault, Partial-Earth, Localisation of a, in a Submarine Cable, 530.
Field-Telegraph Cavalry Corps, Formation of a, in France, 700.
Fire Alarm, New Street, 218.
Floods, Recent, and the Telegraphs, 527.
Florida, A Plucky Staff in, 83.
Forth Telegraph Cables, The, 527.
Fredericia-Calais Cable, The, 185.
Galvanised Iron Line Wire, 223.
Gisborne, Mr., on Telegraphy and Telephony, 242.
Glasgow and the North-West of England, Extension of the Telegraph between, 186.
Glasgow Telegraph Staff, The, and Sir John Pender, 329, 360.
Gold Fields, South African, The Telegraph at the, 241, 585.
Hansell, Harold W., and Young, Julian E., On the Localisation of a Partial-Earth Fault in a Submarine Cable by Fall of the Fault's Natural Potential, 530.
Hempen-Covered Cables, 422, 468.
Hooper's Compound, Efficacy of, 327.
India, Telegraphic Communication with, 242.
Indian Telegraph Service, The, 68, 528, 567.
Indian Telegraphs Staff, The, 269, 449.
Indo-Persian Telegraphs, 476.
International Telegraph Convention, 213.
Interruptions of Cables, 3, 185, 389, 527.
Iron Sheathing and Speed in Long Cables, 645.
Italian Cables, The, 423.
Italian Telegraphs, 299, 643.
Java-Australian Cable, New Triplicate, 476, 611.
Johannesberg, Telegraphic Communication with, 585.
Lectures, Popular, 529.
Lightning Conductors, Experimental, 2, 641, 646.
Lightning, Effects of, on Telegraph Lines, 126.
Localisation of a Partial-Earth Fault in a Submarine Cable, 530.
Long Cables, Iron Sheathing and Speed in, 645.
Mackay, Mr., Presentation to, 270.
Memoranda with regard to the Erection of Experimental Lightning Conductors at Telegraph Stations Abroad, 646.
Mexican Cable, New, 389, 424.
Military Telegraphs, 269.
Mines, Telegraphs in, 502.
Money Orders, Telegraphic, 501.
Morocco Cable, The, 558, 583, 585.
Morse Instrument, An Improved, 500.
Mounted Telegraph Corps, Formation of a, in France, 700.
Multiplex Telegraphy, Lieut. Patten's System of, 422, 519.
New Mexican Cable, 389, 424.
New Zealand, Telegraph Extension in, 126.
Nicaragua and the West Indies, Proposed Submarine Cable between, 125.
Ocean Temperatures in Relation to Submarine Cables, 25, 48, 86, 148.
Overhead Wire Question, The, in Brooklyn, 529
Pacific Cable Scheme, The, 35, 65, 89, 91, 158.
Parliament, Discussion on the Post Office Telegraph Service in, 636.
Patten's, Lieut., System of Multiplex Telegraphy, 422, 519.
Pender, Sir John, and the Glasgow Telegraph Staff, 329, 360.
Periodicity of Earth Currents, 519.
Phenomena, Certain, connected with Imperfect Earth in Telegraph Circuits, 453, 480.
Phonograph, The, in Telegraphy, 125.
Phonopore, The, 582, 614.
Portraits of Cable Celebrities, 583.
Popular Lectures, 529.
Post Office, The, and the Continental Cables, 613.
Post Office Telegraph Service, The, 558, 611, 636.
Preece, W. H., On Self-Induction and Retardation, 101.
Presentation to Mr. Mackay, 270.
Press, The American, and the Telegraph, 283,
Progress of Telegraphy, 424, 529.
Race Meetings and Telegraphy, 698.
Rates to the Continent, The New, 611, 642.
Reduction of Telegraph Rates in Sweden, 576.
Relay, The Burke, 576.
Repairs of Cables, 37, 241, 359, 385, 449.
Revenue, The Post Office Telegraph, 611.
Rival Telegraph Companies in the West Indies, 346.
River Plate, Telegraph Development at the, 241.
Russo-Chinese Telegraph, 345.
Siberia, A Telegraph across, 345.
Siemens' Recording Apparatus for Compact Morse Writing, 500, 505.
Signalling Apparatus, Electric, for Night Watchmen, 260.
South African Cables, Extension of the, 82 (*with map*), 473, 476, 583, 674, 726.
South African Gold Fields, The Telegraph at the, 241, 585.
South America, Reduction of Tariff to, 557.
Spanish-Cuban Cable, Proposed, 584.
Snow, Damage to Wires by, 423, 466.
Statistics, Italian Telegraph, 299.
Stock Exchange "Tickers" in America, 229.
Street Fire Alarm, New, 243.
Suakim, The Battle at, 185.
Submarine Cable, New, 643.
Submarine Cable Concession, A, in Brazil, 97.
Submarine Cable, Localisation of a Partial-Earth Fault in a, 530.
Submarine Cables, Ocean Temperatures in Relation to, 25, 48, 86, 148.
Submarine Telegraph Extensions, 215, 327.
Sweden, Telegraph Tariffs in, 23, 576.
Swedish State Telegraphs, The, and the Stockholm General Telephone Company, 172.
Telautograph, The, 203.
Telegraphers' Mutual Benefit Association, The, 171.
Telegraphy without Wires, 24, 25, 56, 57, 348, 378, 412.
Tell-Tale, An Electric.
Testing, Cable, 86, 148.
"Tickers," Stock Exchange, in America, 225.
Tonkin and China, Telegraph Line between, 673.
Transvaal, The Telegraph in the, 185, 241, 585.
Trinidad-Demerara Cable, The, 3, 37, 241.
Uruguay, Telegraphs and Telephones in, 728.
Van Rysselberghe System, The, 124, 125.
Venezuelan Telegraphs, 3.
Weather Predictions, Usefulness of the Bermuda Cable for, 675.
West Africa, Cable Extension in, 327, 476, 674.
West Indies, Rival Telegraph Companies in the, 346.
Western Union and Baltimore and Ohio Companies, Action against the, for Consolidation, 317.
Western Union Company, The, and the Board of Electrical Control, 748.
Western Union Telegraph Company, Statistics of the, 68, 202, 258, 283, 317, 633.
Wire, Galvanised Iron Line, 223.
Wires, Telegraphy without, 24, 25, 56, 57, 348, 378, 412.
Young, Julian E., and Hansell, Harold W., On the Localisation of a Partial-Earth Fault in a Submarine Cable by Fall of the Fault's Natural Potential, 530.

Telephones.

Accident caused by the Telephone at Montreux, 48.
Africa, West Coast of, The Telephone on the, 185.
Amalgamation, Telephone, 556, 642, 697, 725.
America, The Bell Patents in, 35, 52, 114, 228, 492, 519.
American Coast, The Telephone on the, 171.
Amsterdam and Rotterdam, Telephone between, 269.
Austria, The Telephone in, 172, 425, 467, 601.
Automatic Cash Boxes for Public Call Offices, 352.
Barney's Make-and-Break Telephone, 299.
Bell Telephone Company (American), Statistics of the, 202, 258, 283, 319, 691.
Bell Telephone Patents, The, in America, 35, 52, 114, 228, 492, 519.
Berne and Geneva, Telephone between, 185.
Brisbane, The Telephone at, 390.
Buenos-Ayres and Montevideo, Telephone between, 124.
Burton-on-Trent, The Telephone at, 501.
Call Office, Telephone, The First, 24, 57, 87, 117, 149.
Call Rooms, Telephone, in London, 558.
Chatham, The Telephone at, 674.
Clock Regulation, Utilisation of Telephone Systems for Purposes of, 366.
Coast, American, The Telephone on the, 171.
Confessional, The Telephone as an Adjunct to the, 156.
Consolidated Telephone Construction and Maintenance Company, Some New Instruments by the, 58.
Convention, Proposed Telephone, 556, 674.

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Telephones (*continued*).

Copenhagen, The Telephone in, 576.
Derby, The Telephone at, 98.
Devonshire, The Telephone in, 4.
Directory, Pocket Telephone, 269.
Dorchester, The Telephone at, 320.
Edison Patents, The, in France, 347.
Eriksson Microphone, The, 576.
Exchange Buildings in America, 317.
Finland, The Telephone in, 67.
Fire Brigade, The Telephone and the, 243.
Florida, Flucky Electricians in, 83.
French Government, The, and Telephones, 663.
Geneva and Berne, Telephone between, 185.
Gisborne, Mr., on Telegraphy and Telephony, 242.
Hampshire, The Telephone in, 3.
High Tension Currents and Telephone Circuits, 184.
Honolulu, The Telephone in, 214.
Instruments, Some New, by the Consolidated Telephone Construction and Maintenance Company, 58.
International Telephonic System, An, 37.
Leeds, Presentation at, 450.
Life-Saving Service in America, The Telephone and the, 171.
Lisbon-Oporto-Telephone, The, 501.
London, Telephone Call Rooms in, 558.
Long-Distance Telephony, 558.
Luxembourg, The Grand Duchy of, The Telephone in, 53.
Make-and-Break Telephone, Barney's, 290.
Manchester Telephone Staff, Annual *Soirée* of the, 539.
Manresa (Spain), The Telephone at, 423.
Microphone, The Eriksson, 576.
Microphone, The Mix and Genest, 644.
Milan, The Telephone at, 643.
Military Telephony, 269.
Miller, Mr. J. B., Presentation to, 727.
Mishap in Berners-street, 184, 231.
Mix and Genest Microphone, The, 644.
Montreal, The Telephone at, 83.
Montreux, Accident caused by the Telephone at, 48.
Multiplex Telephony on Long Lines, 423.
National Telephone Company, Extensions by the, 9, 98, 501.
News, Rapid Transmission of, by the Telephone, 260.
Northern District Telephone Company, Extensions by the, 3.
Northumberland, The Telephone in, 3.
Nottingham, The Telephone in, 9.
Overhead Wire Question, The, in Brooklyn, 529.
Paris-Brussels Telephone, The, 125.
Paris Exhibition, The Telephone at the, 241.
Paris, Telephony in, 558.
Patents, The Edison, in France, 347.
Pocket Telephone Directory, 269.
Post Office, The, and the Telephone, 612.
Presentation at Leeds, 450.
Progress of Telephony, 425.
Rapid Transmission of News by the Telephone, 260.
Rates, Telephone, in America, 410.
Remarkable Span, A, 611.
Russia, The Telephone in, 576, 643.
Span, A Remarkable, 611.
Stock Exchange, The Telephone at the, 243.
Stockholm, The Telephone at, 412.
Submarine Telephony, 124.
Sweden, The Telephone in, 23, 172.
Switch-Board, New Multiple, at the Westminster Exchange, 125.
Switzerland, The Telephone in, 185.
Switzerland, The Telephone in, 298.
United States, Telephone Rates in the, 601.
Utilisation of Telephone Systems for Purposes of Clock Regulation, 366.
Van Rysselberghe System, The, 124, 125.
Vienna Telephone Company, The, 467, 749.
West Coast of Africa, The Telephone on the, 185.
Westminster Exchange, New Multiple Switch-Board at the, 125.
West of England and South Wales Telephone Company, Extensions by the, 3, 4.
Uruguay, Telegraphs and Telephones in, 728.

Miscellaneous.

Abnormal Magnetisation, Dr. O. J. Lodge on, 183.
Accident to Mr. Edison, 501.
Accumulators, Alkaline, 213, 350, 378, 413.
Aggregation, Influence of State of, on Electrical Resistance, 559.
Agriculture, Electricity in, 20.
Aids, Electrical, to the Drama, 280.
Albion Gas Engine, 289.
Alleged Piracy, 263, 288, 320.
Alloy, A New, 528.
Alloys and Solid Sulphides, The Conduction of, 48, 149.
Alloys, Resistance of, 215.
Alternating Currents, Mr. Harold Brown on, 35, 55.
Alternative Path, Mr. E. G. Acheson on the, 377.
Alternate Current Watt-Meters, 212.
American Electrical Engineers, Visit of, 450.
American Exhibits in the Paris Exhibition, 465.
Ammeter for Large Currents, Paterson and Cooper's, 135.
"Anti-Friction" Steam Packing, 270.
Aqueous Solutions, A Method of Examining Rate of Chemical Change in, 591.
Arc, The Counter E.M.F. of the, 158.
Atkinson, L. B., on the Use of the Integraph in Determining some Problems in Electro Dynamics, 702, 730.
Atmospheric Electricity, Researches in, 77.
Aurora Borealis, The, 338, 379.
Australia, Development of Electrical Engineering in, 1.
Awards at the Brussels Exhibition, 4, 53.
Balloon Signalling, 527.
Barcelona Exhibition, Awards at the, 125, 200.
Barometer, Reading the, at a Distance, 315.
Batteries, Secondary, Patent Rights in, 483, 750.
Battery Resistance Test, Mance's, 634.
Battery, Secondary, M. Faure's New, 117.
Beam of Light, A, as a Conductor, 697.
Bearings, Frictionless, 215.
Bell, Electric, Snelgrove's, 200.
Bells, Magneto-Electric, Cox-Walker-Swinton, 37, 327.
Belting, Wrought-Iron, 298.
Ben Nevis, Electric Effects on, 205.
Berry's Improved Electric Bell, 574.
Birmingham, Electrical and Industrial Exhibition in, 283, 448, 450, 556, 644.
Birthday Surprise, A., for Mr. Edison, 493.
Bleaching, Electric, 494.
Bleaching, Electro-Chemical, The Hermite Process of, 69, 306.
Blondlot and Curie's Electrometer, 212, 261, 287.
Bolts and Nuts, Armstrong's Improved Fastenings for, 269.
Brazil, The India-Rubber Trade of, 450.
Bressa Competitions, The, 389.
British Association, List of Officials for the Forthcoming Meeting of the, 645.
British Museum, Electric Fire Alarm System at the, 644.
Brooks Underground Cable System, The, 643.
Brussels Exhibition Awards, 4, 53.
Bursting of Leyden Jars, Note on the, 586, 616.
Cables, Electric, Factory in Sweden, 576.
Camera Club, The, 727.
Capital Punishment by Electricity, 115, 213, 228, 288, 317, 575, 601.
Cardew Patents, The, 214.
Casing, Wood, for Electric Wires, 98, 450.
Casting, Large, for the Deptford Station, 673.
Caustic Potash and Bromine Elements, 270.
Centenary of Ohm, The, 359, 390, 448, 557.
Centro Technico dos Electricistas Brazileiros, The, at Rio de Janeiro, 213.
Chamber of Commerce, London, Annual Report of the, 557.
Chamber of Commerce, London, Electrical and Allied Trades Section of the, 30, 38, 582, 610, 641.
Chancellor of the Exchequer, The, upon the Post Office, 699.
Chemical Change in Aqueous Solutions, A Method of Examining Rate of, 591.
Chemistry, A New Method of Teaching, 612.
Chenowith Conduit Core, The, 715.
City and Guilds Institute, Satisfactory Progress of the, 729.
City and Guilds of London Old Students' Association, The, 66.
City and Guilds of London Technical College, 214.
City and Guilds of London Technical Institute, The, 185.
City Notes, 33, 63, 93, 121, 153, 181, 209, 237, 265, 293, 323, 355, 385, 419, 445, 471, 497, 523, 553, 579, 607, 639, 669, 695, 723, 753.
Civil Engineers, Institution of, Progress of the, 242.
Clark Cell, The, as a Source of Standard Currents, and its Application to the Calibration of Sensitive Long Range Galvanometers, 590.
Cleveland Electric Heating Hoax, The, 327.
Coal-Cutting Machines, Electrical, 282.
Coast Defences, 126.
Cobalt, The Electric Resistance of, in the Magnetic Field, 213.
Coefficient of Mutual Induction, The, of a Helix and a Coaxial Circle, 75.
Combination Kerb and Gutter Conduit, 716.
Commutators, The Wearing of, 68.

COMPANIES' MEETINGS, REPORTS, DIVIDENDS, &c.

(Abbreviations:—Div., Dividend; Mtg., Meetings of Shareholders; Rev., Revenue; Rpt., Reports of Directors.)

Allgemeine Elektricitäts-Gesellschaft—691.
American Bell Telephone Company—691; Div., 258.
Anglo-American Brush Electric Light Corporation—753; Rpt., 521; Mtg., 550.
Anglo-American Telegraph Company—Div., 355; 639; Rpt., 384; Mtg., 417.
Anglo-Portuguese Telephone Company—209; Rpt., 723.
Australasian Electric Light, Power, and Storage Company—Rpt., 32; Mtg., 60.
Baker (Charles L.) and Co.—Mtg., 237.
Bell's Asbestos Company—Rpt., 355.
Blackpool Electric Tramway Company—Mtg., 120.
Brazilian Submarine Telegraph Company—153, 611, 676; Rev., 33, 63, 93, 121, 153, 181, 209, 237, 265, 293, 323, 355, 385, 419, 445, 471, 497, 523, 553, 579, 607, 669, 695, 723; Div., 553; Rpt. 752; Mtg., 578.
Brighton and Hove Electric Light Company—Rpt., 470; Mtg., 521.
British Electric Light Company—97, 611.
Callender's Bitumen Telegraph and Waterproof Company—723.
Consolidated Telephone Construction and Maintenance Company—Div., 753.
Crompton and Co.—Div., 419; Mtg., 118.
Cuba Submarine Telegraph Company—Rev, 33, 153, 293, 355, 419, 523, 639; Rpt., 385; Mtg., 416.
Direct Spanish Telegraph Company—Rev., 33, 153, 293, 419, 523, 639; Div., 523; Rpt., 553; Mtg., 603.
Direct United States Cable Company—Div., 323, 695; Rpt., 322; Mtg., 383.
Eastern and South African Telegraph Company—33.
Eastern Extension, Australasia and China Telegraph Company—323, 669; Rev., 35, 153, 293, 419, 523; Div., 209, 607; Rpt., 638; Mtg., 664.
Eastern Telegraph Company—37, 93, 355, 385, 669; Rev., 33, 153, 293, 419, 523, 635; Div, 209, 537; Rpt., 323; Mtg., 88, 353, 381.
Edmundson's—Mtg., 637.
Electrical Automatic Delivery Box Company—Mtg., 669.
Electrical Power Storage Company—Rpt., 639; Mtg., 665.
Electric Date and Time Stamp Company—695.
Elmore's Patent Copper Depositing Company—355.
Equitable Telephone Association—323.
German Union Telegraph and Trust Company—Mtg., 353, 417.
Gill (Arthur B.) and Co.—497.
Globe Telegraph and Trust Company—Div., 323, 607.
Great Northern Telegraph Company—Rev., 33, 153, 293, 419, 523, 635; Rpt., 723; Mtg., 751.
India Rubber, Gutta Percha, and Telegraph Works Company—Rpt., 419; Mtg., 444.
Indo-European Telegraph Company—Div., 669; Rpt., 695; Mtg., 750.
Lancashire and Cheshire Telephonic Exchange Company—Div., 497.
Liverpool Electric Supply Company—Mtg., 637.
London and Provincial Electric Lighting and Power Generating Company—419.
London Electric Supply Corporation—20, 471; Mtg., 234.
Madrid Telephone Company (Sociedad Telefonos de Madrid)—Div., 265.
Manchester Edison-Swan Company—Mtg., 355.
Maxim-Weston Electric Company—120; Mtg., 151, 237, 291.
Metropolitan Electric Supply Company—293; Mtg., 233, 291, 384.
Mexican Telegraph Cable Company—Div., 33: Rpt., 467.
Mining and General Electric Lamp Company—97, 181.
Mix and Genest Company—753.
Montevidean and Brazilian Telegraph Company—Mtg., 667.
Monte Video Telephone Company—Div., 579.
National Telephone Company—Rpt., 385.
New Portable Electric Lamp and Power Syndicate Company—639.
Oriental Telephone Company—Div., 553; Rpt., 638; Mtg., 693.
Pilsen-Joel and General Electric Light Company—Mtg., 119, 207, 292.
Reuter's Telegram Company—265; Rpt., 669; Mtg., 694.
River Plate Telephone and Electric Light Company—181.
South of England Telephone Company—Div., 33, 745; Mtg., 88, 209.
Submarine Cables Trust—33.
Submarine Telegraph Company—Div., 445; Rep., 470; Mtg., 496, 604.
Swan United Electric Light Company—Rpt., 181; Mtg., 208.
Taunton Electric Lighting Company—Rpt., 385; Mtg., 419.
Telegraph Construction and Maintenance Company—121; Div., 419; Rpt., 470; Mtg., 495.
Telephone Company of Austria—209; Div., 639.
Telephone Company of Egypt—Rpt. and Mtg., 552.
Telephone Company of Ireland—Rpt., 667; Mtg., 667.
Thomson-Houston Electric Company—633.
United River Plate Telephone Company—Div., 254.
United Telephone Company—Div., 93.
West African Telegraph Company—93.
West Coast of America Telegraph Company—Rev., 33, 153, 293, 419, 523; Div., 265; Rept. 753.
Western and Brazilian Telegraph Company—Rev., 33, 63, 93, 121, 153, 181, 209, 237, 265, 293, 323, 355, 385, 419, 445, 471, 497, 523, 553, 579, 607, 639, 669, 695, 723; Div. 745.

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Miscellaneous (*continued*).

COMPANIES' MEETINGS, &c. (*continued*)—
Western Counties and South Wales Telephone Company—Rpt., 579; Mtg., 322, 637.
Western Union Telegraph Company—68; Div., 258.
West India and Panama Telegraph Company—Rev., 33, 93, 153, 237, 355, 419, 471, 523, 579, 639, 669, 723; Rpt., 32, 752; Mtg. 59.
Woodhouse and Rawson—Mtg., 207.

Companies Share List, 34, 64, 94, 122, 154, 182, 210, 238, 266, 294, 324, 356, 386, 420, 446, 472, 498, 524, 554, 580, 608, 640, 670, 696, 724, 756.
Compass, The, Superseded, 239.
Concert and Dinner, Annual, The Eastern Telegraph Company's, 265.
Conduction, The Transition from Metallic to Electrolytic, 199.
Conduit Explosions in New York, 672, 675.
Conduits, Electrical, Gas Mains as, 502.
Conduits, Underground, and Electrical Conductors, 544, 718.
Conference on International Patent Law, 583.
Convection Currents, Experiment on the Magnetic Effect of, 155.
Copper, 284, 500, 502, 525, 633, 728.
Copper Syndicate, Collapse of the, 633.
Copper, The Standard Conductivity of, 117, 149.
Copper Wire, Manufacture of, by Elmore's Electro-Burnishing Process, 47, 97, 148, 173, 204.
Copying Drawings, &c., A New Method of, 701.
Corner in Zinc, A, 37.
Counter, An Electricity, 270.
Counter E.M.F. of the Arc, The, 158.
County Councillors, Election of, 269.
Cowles Patents, The, in Germany, 644.
Cox-Walker-Swinton Magneto-Electric Bells, 37, 327.
Cricket, 97.
Crown Prince of Austria, The Late, and Electricity, 467.
Cupidoscope, The, 389.
Current Elements, Rational, Mutual Action of a Pair of, 229.
Curves, Tracing, A New Method of, by Photography, 299.
Damage by Lightning, 644.
Dark Flash, The, seen in some Lightning Photographs, 677.
D'Arsonval Galvanometer, The, 408.
Date and Time Stamp, An Electric, 389.
Death, Supposed, from Electricity, 38.
Deaths by Lightning, 699, 727.
Defence, Electricity our, 14, 261.
Deflection of an Electro-Magnetic Wave by Motion of the Medium, 664.
Directory and Handbook, The Electrical Trades', 105.
Discharge of a Leyden Jar, the, 531.
Dissolved Chemical Compounds and their Combining Proportions, A Method of Detecting, 718.
Dissolved Chemical Compound's, Relative Amounts of Voltaic Energy of, 565.
Divergence, The, of Electromotive Forces from Thermo-Chemical Data, 374.
Dog-Killing Experiments, Mr. Harold P. Brown's, 35, 55.
Doulton Conduit, The, 714.
Drama, Electrical Aids to the, 280.
Drawings, &c., Copying, A New Method of, 701.
Duration of Lightning Flashes, 135.
Duties on Electrical Apparatus Imported into France, 612.
Dynamo Mishap, A, 701.
Dynamo Regulation by Means of a Third Brush, 183, 217, 256, 440.
Dynamo, Relation between Magnetisation and Speed in the, 374.
Earth, The Use of, for Electric Lighting Purposes, 610, 618.
Eastern Telegraph Company's Annual Concert and Dinner, 265.
"Edison and His Inventions," Mr. W. J. Hammer on, 491.
Edison, Mr., A Birthday Surprise for, 493.
Edison, Mr., Accident to, 501.
Edisonia, 700.
Edison's Chemical Meter, Six Years' Experience with, 258.
Edison's Talking Daily Paper, 203.
Edmunds' Distributor, The, 110.
Education of Electrical Engineers, The, 720.
Education, Technical, 30, 263, 264.
Election Intelligence, 241, 269.
Electrical Theory, 24, 54, 173, 204.
Electricity and the Monthly Magazines, 720.
Electricity applied to Tanning, 23.
Electricity in Agriculture, 20.
Electricity our Defence, 14, 261.
Electro-Calorimetry, 24.
Electroliers, Artistic, 111.
Electrolysis, The Theory of, 459, 493, 676, 691.
Electrolytes, The Resistance of, to the Passage of Very Rapidly Alternating Currents, 555, 561.
Electrolytic Separation and Refining of Metals, The: Historical Sketch, 426.
Electro-Magnetic Capacity, A Modification of the Ordinary Method of Determining, 169.
Electro-Magnetic Effect of a Moving Charge, 83, 147.
Electro-Magnetic Induction, Notes on, 6, 40, 100, 160, 216, 244, 272, 300, 392, 478, 504, 560.
Electro-Magnetic Rotation of the Plane of Polarisation, 1.
Electro-Magnetic Waves and the Propagation of Potential, 23.
Electrometer, Blondlot and Curie's, 212, 261, 287.
Electro-Physiology, Prof. Stirling on, 127.
Electroplating, The Jubilee of, 328.
Electrostatic Measurement of Potential, The, 421.
Electrotherapeutics, 557.
Elements, Caustic Potash and Bromine, 270.
Elliott Cresson Medal, The, 674.
Elmore's Electro-Burnishing Process, Manufacture of Copper Wire by, 47, 97, 148, 173, 204.
Enamel as an Insulator, 520.
Energy, Electrical, and Solar Radiation, 559.
Engine, High-Speed, The Richardson, 602.
Engraving by Electricity, 449.
Entertainment at Ponder's End, 584.
Ether, Electricity and Ponderable Matter, 303, 308, 331, 351, 362, 379, 380.
Ether, The, 24.
Events, Electrical, for 1888, Summary of, 253.
Exhibition, Electrical and Industrial, in Birmingham, 283, 448, 450, 556, 644.
Exhibition, International Novelties, 644.
Experimental Lightning Conductors, 2, 641, 646.
Fahrig's Influence Machine, 205.
Financial Position, The, of the London Electric Supply Corporation, 20.
Fire Alarm, Street, New, 243.
Fire Alarm System, Electric, at the British Museum, 644.
Fire at Messrs. Willans and Robinson's, 38, 187.
Fire at the Melbourne Exhibition, 297.
Fleming, Dr. J. A.: Notes on Electro-Magnetic Induction, 6, 40, 100, 160, 216, 244, 272, 300, 392, 478, 504, 560.
Fog, Electrical Dissipation of, 213, 260, 267, 285, 295.
Football, 121.
Formulæ, Transition, between the Electromagnetic and Electrostatic Systems, 451.
France, Duties on Electrical Apparatus Imported into, 612.
Frictionless Bearings, 215.
Galvanometer, The D'Arsonval, 408.
Gas Engine, The Albion, 289.
Gas Interest, The Alarm of the, 2.
Gas Mains as Electrical Conduits, 502.
Gases, The Liquefaction of, by Electricity, 528.
Geneva, Strange Lightning Phenomena at, 5.
German Nomenclature, 232.
Globular Lighting, 56, 117, 222, 271, 390, 413, 443, 520, 720.
Gordon Conduit, The, 716.
Gore, Dr. G., on the Electrolytic Separation and Refining of Metals, 426.
Hammer, Mr. W. J., on "Edison and His Inventions," 491.
Hanover-square School of Electrical Engineering, The, 390.
Heat, Effect of, on the Magnetic Susceptibility of Nickel, 677.
Heat, Radiant, Instruments for the Measurement of, 583, 611.
Heating, Electric Hoax, The Cleveland, 327.
Helmholtz's Jet of Steam Experiment, 239.
Hermite Process, The, of Electro-Chemical Bleaching, 69, 306.
Hertz's Researches on Electrical Oscillations, 16, 41.
High-Resistance Liquids, Specific Resistance and Temperature Coefficient of, 557.
Hurlbut Conduit, The, 714.
Hydrometer, The Holden, 578.
Hypothesis, Simple, Sir William Thomson's, 147.
Improvements in Secondary Battery Plates, 38.
Index, Subject Matter of Patents, The New, 297.
India-Rubber Trade of Brazil, The, 450.
Influence Machine, Fahrig's, 205.
Influence of State of Aggregation on Electrical Resistance, 559.
Institute of Medical Electricity, 327.
Institution of Electrical Engineers, The Election of the Council of, 318, 325.
Insulation Knife, An, 501.
Insulation Resistance, A 10,000-Volt Transformer for Testing, 281.
Insulator, Quartz as an, 673, 678.
Integraph, The Use of the, in Determining Some Problems in Electro-Dynamics, 702, 730.
International Congress of Electricians, 155, 175, 243.
International Patent Law, Conference on, 583.
Irish Conduit, The, 716.
Iron and other Magnetic Metals, Magnetisation of, in very Strong Fields, 102.
Iron, Magnetisation of, at High Temperatures, 678.
Iron, Magnetisation of, The Effect of Light upon the, 555, 574.
Iron, Soft, Magnetisation of, 24.
Johnson Iron Conduit, The, 715.
Jubilee, The, of Electroplating, 328.
Kensington Parliament, A Bill for Promoting Technical Education in the, 264.
Kohlrausch, Prof., on the Electric Resistance and Magnetic Permeability of Metals at High Temperatures, 676.
Knife, An Insulation, 501.
Laboratories, Standardising, 267, 725.
Lake Conduit, The, 714.
Large Casting for the Deptford Station, 673.
Lectures, Popular, 529.
Leeds Mechanics' Institute, 327.

LEGAL INTELLIGENCE.
Anglo-American Brush Electric Light Corporation *v.* Orient Steam Navigation Company, 52.
Cardiff Electric Engineering Company, *Re*, 664.
Chamberlain *v.* Midland Electric Light Company, 636.
Durtnall *v.* Shippey Brothers, 664, 692.
Edison and Swan Electric Light Company *v.* Holland and Others, 143, 175, 200, 219, 226, (*Judgment*) 461.
Faure Electric Accumulator Company, *Re*, (*Judgment*) 51.
Gaulard and Gibb's Patent, *Re*, 315, 343, 375, 409, (*Judgment*) 516.
King, Brown and Co. *v.* Anglo-American Brush Electric Light Corporation, 111, 140, 177, 490, 545.
London Electric Supply Corporation *v.* Roberts, jun., 405.

LEGAL INTELLIGENCE (*continued*)—
Maxim-Weston Electric Company *v.* Watt, 227.
United Telephone Company *v.* Edward Paterson, 181.
United Telephone Company *v.* Ericsson-Bell Telephone Company, 181.
United Telephone Company *v.* New Telephone Company, 681.
United Telephone Company *v.* Siemens Bros. and Co., 664.
Watt *v.* Maxim-Weston Electric Company, 227, 409.

Letters for Learners and Un-Professional Readers, 44, 78, 138, 191, 248, 334, 401, 433, 479, 539, 595, 657, 710.
Leyden Jar Discharges, Magnetism of Steel Needles by, 204.
Leyden Jar Discharges, 499, 525, 531.
Leyden Jars, Note on the Bursting of, 586, 616.
Light, A Beam of, as a Conductor, 697.
Light, Electricity and, 612.
Light, On the Action of, on Statical Charges, 87.
Light, Rotation of the Plane of Polarisation of, by the Discharge of a Leyden Jar, 564.
Light, The Effect of, upon the Magnetisation of Iron, 574.
Lightning, Account of a House Struck by, at Lisbon, 72.
Lightning, A Crew Disabled by, 99.
Lightning Arresters and the Photographic Study of Self-Induction, 377.
Lightning Conductors, A Complete History of, 504.
Lightning Conductors, Dr. O. J. Lodge on, 7, 70, 128, 161 188, 245, 646, 726, 731, 749.
Lightning, Damage by, 644.
Lightning, Deaths by, 699, 727.
Lightning, Effects of, on Telegraph Wires, 126.
Lightning Flashes, Duration of, 135.
Lightning Flashes, Motion of, 116.
Lightning, Globular, 56, 117, 271, 390, 413, 443, 520, 720
Lightning Guard, The Wehr, 674.
Lightning Phenomena, Strange, at Geneva, 5.
Lightning, Photographs of, 721.
Lightning Photographs, The Dark Flash seen in some, 677.
Lightning Stroke, Curious Effect of a, 157.
Liquefaction of Gases, The, by Electricity, 528.
Liquids, High-Resistance, Specific Resistance and Temperature Coefficient of, 557.
Liquids, Specific Inductive Capacity of, 600.
Lisbon, Account of a House Struck by Lightning at, 72.
Lissajou's Figures, The Use of, for Determining Speed of Rotation, 589.
Lithanode, 360.
Lodge, Dr. O. J., on Lightning Conductors, 7, 70, 128, 161, 188, 245, 646, 726, 731, 749.
Lodge, Dr. O. J., on Modern Views of Electricity, 407.
Lodge, Dr. O. J., on the Bursting of Leyden Jars, 586, 616.
London County Council, The, and Overhead Wires, 674.
Loss of Voltaic Energy of Electrolytes, The, during Chemical Union, 626.
Magnetic Action of Displacement Currents in a Dielectric, The, 499.
Magnetisation of Iron and other Magnetic Metals in very Strong Fields, 102.
Magnetisation of Iron at High Temperatures, 678.
Magnetisation of Soft Iron, 24.
Magnetism of Steel Needles by Leyden Jar Discharges, 204.
Magnetism, Some Curiosities of, 423.
Mance's Battery Resistance Test 634.
Maxwell's Theory, A Crucial Test of the Truth of, 525.
Measurement, Electrical, 489 513.
Medical Electricity, 558.
Medical Electricity, Institute of, 327.
Melbourne Exhibition Awards, 157, 475, 501, 673.
Melbourne Exhibition, Fire at the, 297.
Mendacity, Physical Science a Cure for, 67.
Mercury, Absolute Resistance of, 424.
Metallic Plates, The Electrification of, by Illumination with the Electric Light, 409.
Metals, The Electric Resistances and Magnetic Permeability of, at High Temperatures, 679.
Metals, The Electrolytic Separation and Refining of: Historical Sketch, 426.
Meteorological Instruments, Tenth Annual Exhibition of, 425 528, 583.
Meter, Electric, Competition in Paris, 298, 328.
Method of Detecting Dissolved Chemical Compounds and their Combining Proportions, 718.
Mining, Electricity and, 3, 4, 53, 502.
Mishap, A Dynamo, 701.
"Modern Views of Electricity," 1, 407.
"Modern Views with respect to Electric Currents," 575.
Modification, A, of the Ordinary Method of Determining Electro-Magnetic Capacity, 169.
Motor Competition, Society of Arts, 424, 527, 548, 584.
Movement, Undulatory, The Existence of an, accompanying the Electric Spark, 224.
Multipliers, Tangent Function, to be Used with the Kapp Formulæ in the Design of Dynamos and Motors, 337.
Mutual Action of a Pair of Rational Current Elements, 229.
Narr, F., on the Action of Light on Statical Charges, 87
Navy, Electricity in the, 213.

NEW COMPANIES REGISTERED.
Bath Electric Light Company, 607.
British Electric Tramways and General Syndicate, 209.
British Tanning Company, 695.
Brompton Electric Fittings Company, 753.
Crompton and Co., 33.
Douglas Patent Clock and Electric Meter Company 93.
Douse's Patent Fire Check Company, 209.
Electro-Galvanic Machine Company, 293.
Elmore's Patent Copper Depositing Company, 354.

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Miscellaneous (*continued*).

NEW COMPANIES (*continued*)—
Graphophone Syndicate, 471.
Great Marlow Water Company, 523.
Gutensohn and James, 735.
Halifax Mutual Electric Light and Power Co., 639.
Laing, Wharton and Down Construction Syndicate, 607.
Lancashire Electric and Engineering Company, 93.
Maxim-Weston Electric Company, 355.
Miner's Lamp Electric Lighting Company, 355.
Mines and General Telpher Company, 471.
Mining and General Electric Lamp Company, 121.
Mix and Genest Company, 735.
Newcastle and District Electric Lighting Co., 355.
Newcastle-upon-Tyne Electric Supply Company, 323.
Northampton Electric Light and Power Co., 669.
Nottingham Electric Light and Power Company, 523.
Page (E.) and Company, 203.
Patentees Company, 735.
Planet Electrical Engineering Company, 639.
Railway Automatic Electric Light Syndicate, 523.
River Plate Electricity Company, 445.
Sunderland and District Electricity Supply Co., 471.
Sungie Ujong (Malay Peninsula) Railway Co., 121.
Windsor and Eton Electric Light Company, 121.

New South Wales, Electrical Institute of, Formation of the, 99.
Niagara, Plans for Utilising the Water-Power of, 466.
Nickel, Magnetic Susceptibility of, Effect of Heat on the, 677.
Nomenclature, German, 232.
Novels and Electricity, 258.
Novelties Exhibition, International, 644.
Nuts and Bolts, Armstrong's Improved Fastenings for, 269.

OBITUARY NOTICES.
Brooke, Sir William O'Shaughnessy, 297.
de la Rue, Warren, 709.
Fuller, J. W., 653.
Gaulard, Lucien, 107, 117.
Mancha Joaquin de, 528.
Newall, Robert Stirling, 728.
Patey, Charles Henry Bennet, C.B., 623.
Werndl, M., 749.

Occlusion of Gases, The, in the Electrolysis of Sulphate of Copper, 391.
Ohm Memorial, The, 359, 390, 448, 557.
Oscillations, Electrical, Hertz's Researches on, 16, 41.
Ostwald's Experiments on Electrolytic Dissociation, 493, 676, 691.
Overhead Wires *v.* Underground Wires, 116, 529.
Overhead Wires, The Government and, 67, 644.
Overhead Wires, The London County Council and, 674.
Packing, Steam, "Anti-Friction," 270.
Paris Exhibition, American Exhibits in the, 465.
Paris Exhibition, The, 125, 157, 284.
Parliamentary Intelligence, 221, 636.
Patent Designs and Trade Marks Bill, The, 109, 213.
Patent Law in the United States, 388, 410, 425, 483.
Patent Record, 31, 91, 232, 263, 289, 321, 352, 380, 416, 443, 469, 603, 634, 692, 722.
Patents on Electrical and Related Inventions issued by the United States Patent Office in 1888, 465.
Patents, Renewal of, 67.
Paterson and Cooper's Ammeter for Large Currents, 135.
Pender, Sir John, 699.
People's Palace Technical Schools, The, 126.
Personal Notices, 3, 153, 213, 260, 449, 497, 523, 553, 579, 607, 669, 695, 723, 753.
Phonograph, The, 125, 645.
Photographic Study of Self-Induction, The, 388.
Photographs of Lightning, 721.
Photography, A New Method of Tracing Curves by, 299.
Photometer, Dr. Summer's, 391.
Physical Quantities, The Suppressed Dimensions of, 108.
Physiological Effects of Alternating Currents, The, 350, 378.
Physiology, Electro, Prof. Stirling on, 127.
Piezometer, The, for Deep-Sea Sounding, 55.
Piracy, Alleged, 263, 288, 320.
Plane of Polarisation, Electro-Magnetic Rotation of the, 1.
Popular Lectures, 529.
Post Office, The Chancellor of the Exchequer upon the, 699.
Preece, Mr., on Secondary Batteries, 726, 734.
Programme, Provisional, of the International Electrical Congress at Paris, 174.
Quackery, Electrical, 698.
Quartz as an Insulator, 673, 678.
Radiant Heat, Instruments for the Measurement of, 583, 611.
Radiometer, The, 68.
Reading the Barometer at a Distance, 315.
Reed or Tuning Fork, Direct Determination of the Vibration Period of a, by Means of a Morse Receiver, 589.
Relation between Magnetisation and Speed in the Dynamo Machine, 374.
Relative Amounts of Voltaic Energy of Dissolved Chemical Compounds, 565.
Relative Amounts of Voltaic Energy of Electrolytes, 626.
Removal Notices, 94, 209, 293, 323, 497, 579, 669, 753.
Reporters, Exclusion of, at the Institution of Electrical Engineers, 325.
Researches in Atmospheric Electricity, 77.
Resistance, Absolute, of Mercury, 424.
Resistance Coil, Standard, A Form of, 74.
Resistance, Electrical, Influence of State of Aggregation on, 559.
Resistance, High Specific, The Measurement of, 625.
Resistance of Alloys, 215.
Resistance of Electrolytes, The, to the Passage of Very Rapidly Alternating Currents, 561.
Resistance of Imperfectly Purified Sulphur, Measurement of the, 625.
Retardation and Self-Induction, 101.

REVIEWS OF BOOKS, &c.
Accumulatoren für Elektricität, Die (Edmund Hoppe), 164.
Bell-Hanger's Handbook, The (F. B. Badt), 337.
Calendar for Electricians, 248.
Calvert's Mechanics' Almanack, 157.
Carpmael's Patent Laws of the World, Supplement to, 563.
Central Station Electric Lighting: with Notes on the Methods used for the Distribution of Electricity (Killingworth Hedges), 12.
Compteurs d'Energie Electrique, Le (E. Hospitalier), 486.
Dynamo-Electric Machinery: A Manual for Students of Electro-Technics (Silvanus P. Thompson), 275.
Electric Bells, and all about them (S. R. Bottone), 165.
Electric Motor, The, and its Applications (T. C. Martin and J. Wetzler), 336.
Electrician Electrical Trades' Directory and Handbook, The, 428.
Electricity in the Service of Man (A. R. Von Urbanitsky), 509.
Elements of Electric Lighting, The, including Electric Generation, Measurement, Storage and Distribution (Philip Atkinson), 165, 231.
Erzeugung und Verteilung, Die, der Elektrizität in Zentral-Stationen (Mortin Krieg), 336.
Gas Engineers' Annual, The, 429.
Gleanings in Science: a Series of Popular Lectures on Scientific Subjects (Gerald Molloy), 509.
Glimpses of Feverland; or, A Cruise in West African Waters (A. P. Crouch), 564.
How to Make a Dynamo (Alfred Crofts), 647.
Index of Publications on Methods of Communication in the Field, and on Torpedo Warfare (R. Von Fischer Treuenfold), 509.
Kirchhoff's Laws and their Application (E. C. Rimington), 12.
Laxton's Price Book (1889), 423.
L'Electricité à la Maison (Julien Lefévre), 508.
Life of Sir William Siemens, F.R.S., D.C.L., LL.D., &c. (William Pole), 456.
Manufacturer, The, 279.
Mechanical Drawing: A First Course (G. Halliday), 308 (*see also* 389).
Model Engineer's Handy Book, The, 509.
Notice sur le Concours, 47: Electricité (Brussels Exhibition of 1888), 509.
Our Christmas Annual, 186.
Practical Electrical Measurements (J. Swinburne), 427 (*see also* 468).
Practical, Plane and Solid Geometry (J. S. Rawle), 618.
Projet d'Utilisation de la Puissance d'une Chute d'Eau pour l'Eclairage Electrique d'une Ville (L. Vigreux), 563.
Puck's Girdle, 248.
Scientific Papers, The, of the late Thomas Andrews, M.D., F.R.S., Vice-President and Professor of Chemistry, Queen's College, Belfast, 647.
Street's Indian and Colonial Mercantile Directory, 298.
Télégraphie Actuelle, La (L. Montillot), 246.
Theory and Practice, The, of Absolute Measurements in Electricity and Magnetism (A. Gray), 617.
Treatise on Submarine Telegraphy (E. Wünschendorff), 593, 616.
Voltaic Accumulator, The (Emile Reynier), 509.
Work, 528.
Workman's Electric Lighting Vade Mecum, A, 248.

Rewards for Meritorious Inventions and Discoveries, 57.
Richardson High-Speed Engine, The, 602.
Rio de Janeiro, A New Electro-Technical Society in, 213.
Roberts' Primary Battery, 284.
Robey and Co.'s Engine at Glasgow, 67.
Rotation, Determining Speed of, The Use of Lessajou's Figures for, 589.
Rotation of the Plane of Polarisation of Light by the Discharge of a Leyden Jar, 564.
Rowlands', Prof., Experiment on the Magnetic Effect of Convection Currents, 155.
Royal Society Selected Candidates, 729.
Sayers, W. B., An Account of a House struck by Lightning at Lisbon, 72.
Schanschieff Battery, The, in Belgium, 467.
Secondary Batteries, Patent Rights in, 483, 643, 692, 749, 750.
Secondary Battery, M. Faure's New, 117.
Secondary Battery Plates, Improvements in, 38.
Self-Induction and Retardation, 101.
Self-Induction, The Photographic Study of, 388.
Sewage Purification, Electrolytic Method of, Mr. Webster's, 583, 588.
Shooting Stars, The Incandescence of, 700.
Shunts, Electro-Magnetic, 260.
Signalling, Balloon, 527.
Silver, The Electro-Chemical Equivalent of, 698.
Slotte, K. F., on Incandescent Lamps: Candle-Power and Current, 282.
Smelting, Electric, Patents, Action for Infringing, in the United States, 359.
Smithfield Show, Exhibits at the, 157.
Snakes, Electricity and, 449.
Snelgrove's Electric Bell, 200.
Society of Arts Motor Competition, 424, 527, 548, 584.
Society of Telegraph Engineers, The Council of, 123, 155.
Sodium, Metallic, Economical Production of, 97.
Solar Radiation and Electrical Energy, 559.
"Some Curiosities of Magnetism," 423.
Some Fundamental Points in the Theory of Electrolysis, 459.
Sounding, Deep-Sea, The Piezometer for, 55.
Spain, A New Electrical Journal in, 389.
Specific Inductive Capacity of Liquids, 600.
Stamp, Date and Time, An Electric, 389.
Standard Conductivity of Copper, The, 117, 149.
Standard Types of Electrical Apparatus, 387.
Standardising Laboratories, 267, 725.
Street Fire Alarm, New, 243.
Stress, Electrical, 451.
St. Thomas, Charterhouse, Boys' School, 389.
Subject Matter of Patents Index, The New, 297.
Submarine Mining, 502.
Subways, Electrical, in America, 52, 53, 575.
Sugar, Electric, 2, 125, 268, 346, 449.
Sulphate of Copper, The Occlusion of Gases in the Electrolysis of, 391.
Sulphides, Solid, and Alloys, The Conduction of, 48, 149.
Sulphur, Imperfectly Purified, Measurement of the Resistance of, 625.
Summary of Electrical Events for 1888, 253.
Summer's, Dr., Photometer, 391.
Supper, Annual, of Employés of Messrs. Laing, Wharton and Down, 270.
Supposed Death from Electricity, 38.
Sweden, An Electric Cable Factory in, 576.
Switch-Board Arrangements, Westinghouse Station, 18.
Tangent Function Multipliers to be Used with the Kapp Formulæ in the Design of Dynamos and Motors, 337.
Tanning, Electricity applied to, 23.
Teaching Chemistry, A New Method of, 612.
Technical Education, 36, 263, 264.
Telegraphers' Mutual Benefit Association, The, 171.
Tell-Tale, An Electric, 260.
Thomson Effect, The, 297.
Thomson Electric Welding System, The, 22, 72, 576, 633.
Thomson, Prof. J. J., on the Resistance of Electrolytes to the Passage of very Rapidly Alternating Currents, 561.
Thomson, Sir William, 330.
Thomson's, Sir William, Inaugural Address, 239, 295, 303, 331, 362.
Thomson's, Sir William, Simple Hypothesis, 147.
Trade Catalogues, 4, 21, 125, 193, 242, 321, 359, 361, 424, 501, 502, 557, 612, 727, 728.
Transformer, A 10,000-Volt, for Testing Insulation Resistance, 281.
Transition Formulæ between the Electromagnetic and Electrostatic Systems, 451.
Transition, The, from Metallic to Electrolytic Conduction, 199.
Trotter, Mr. A. P., Appointment of, as Secretary to the Electrical Section, 641.
Tuning Fork or Reed, Direct Determination of the Vibration Period of a, by Means of a Morse Receiver, 589.
Tunzelmann, G. W. de, on Hertz's Researches on Electrical Oscillations, 16, 41.
Underground Cable System, The Brooks, 643.
Underground Conduits and Electrical Conductors, 526, 544, 609, 713, 746.
Undulatory Movement, The Existence of an, accompanying the Electric Spark, 224.
Unit of Electrical Supply, Proposed Alteration of, 65.
"Universal" Galvanometer, The, 408.
Vacuum, The Conductivity of a, 212.
Verity Conduit, The, 714.
Visit of American Electrical Engineers, 450.
Voltaic Energy of Electrolytes, Loss of, during Chemical Union, 626.
Voltaic Energy of Electrolytes, Relative Amounts of, 626.
Voltmeter, Ayrton and Perry's, for Electric Welder, 514.
"V," The Measurement of, 448.
Walker, S. F., on Execution of Electricity, 288.
"War Syndicate, The Great," 258.
Water, Condensed, The Action of Electricity on the Vesicles of, 4.
Watt-Meters, Alternate Current, 212.
Wave, Electro-Magnetic, Deflection of an, by Motion of the Medium, 664.
Wearing of Commutators, The, 68.
Weber, Prof. Leonhard, on Researches in Atmospheric Electricity, 77.
Webster's, Mr., Electrolytic Method of Sewage Purification, 583, 588.
Wehr Lightning Guard, The, 674.
Welding, Electric, The Thomson System of, 22, 72, 576, 633.
Westinghouse Station Switch-Board Arrangement, 18.
Wilkinson, H. D., Letters for Learners and Un-Professional Readers, 44, 78, 138, 191, 248, 334, 401, 433, 479, 539, 595, 657, 710.
Wood Casings for Electric Wires, 98, 450.
Woodhouse and Rawson Manufacturing Company's Works at West Kensington, 150.
Wrought-Iron Belting, 298.
York, Fine Art, Ecclesiastical, Educational and Industrial Exhibition at, 328.
Zinc, A Corner in, 37.

SUPPLEMENTS TO "THE ELECTRICIAN," VOL. XXII.

SOUTH AFRICA, MAP SHOWING EXTENSION OF TELEGRAPHIC COMMUNICATION WITH ..... November 23, 1888.
SOUAKIM, THE ELECTRIC LIGHT AT (*Plan of Fortifications and Harbour*) ..... November 23, 1888.
THOMSON, SIR WILLIAM (*Steel Plate Portrait*) ..... January 25, 1888.

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THE ELECTRICIAN:

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NOTES.

In the chapter on "Modern Views of Electricity," in last week's *Nature*, a very novel explanation is offered (with some reserve) to account for Faraday's experiment of the electro-magnetic rotation of the plane of polarisation. Our readers must be referred to the original Paper for the full explanation, but we may endeavour to give a brief account of the theory as applied by Dr. Oliver Lodge to that form of the experiment (due to Kerr) in which a beam of plane-polarised light is observed to be rotated when reflected from the polished pole of a magnet. This, Dr. Lodge thinks, is an effect of *hysteresis*. First, it must be remembered that undoubtedly "something in the nature of a rotation is going on in a magnetic field around the lines of force," and this rotation, even within the iron itself, we have every reason to believe takes place in the ether. Next, we have to recollect that by an elementary theorem of mechanics any rectilinear vibration in a given plane may be resolved into two equal circular components which rotate in opposite directions around the same periphery. Now, apply this to the electro-magnetic vibrations (of the ether) which constitute the ray of plane-polarised light. In the process of reflection from the polished surface of the iron the ray penetrates to an excessively minute extent into the metal. Here it meets the magnetic whirls, which are all in one direction. One of the two opposite circular components therefore tends infinitesimally to magnetise the iron more strongly, and the other infinitesimally to demagnetise it. But owing to the existence of hysteresis the value of k, or the magnetic susceptibility of the iron, which offers itself to the two components, will be different; hence they will go at different rates and the plane of vibration will be rotated.—If any of our readers are anxious to refresh their memory on the physical aspect of the Maxwellian view of the electro-magnetic field, and are unable to refer to these Papers of Dr. Oliver Lodge, we may direct them *faute de mieux* to *The Electrician* of February 11 and 25, 1887. It is, however, to be hoped that "Modern Views of Electricity" will be republished *in extenso*.

We are this week enabled, by the courtesy of the Board of Trade, to publish a copy of the draft regulations which have been drawn up by the Board in reference to the Kensington Court Electric Supply Company. It must be understood that this is merely a tentative move, and that the Board have expressed their willingness to consider any objection which may be raised on the part of the undertakers. We understand that the subject will be taken into consideration at the next meeting of the Committee of the Electrical Trades, and if any amendment be considered desirable, representations will, no doubt, be made. Although the Board are empowered to make separate and distinct regulations in respect of each station working under a license, yet it may be taken for granted that this, being the first instance of the kind, will serve as a model for all similar installations. The copy has not long been in our hands, and we therefore prefer not to express any opinion of our own for the moment.

At the Grosvenor Gallery Central Lighting Station, on Wednesday evening, and at the hour of midnight, the representatives of the technical press, having previously visited the engine and dynamo rooms (of which a full description will be found on a later page), witnessed a highly interesting experiment with a current of 10,000 volts potential. One hundred 100-volt lamps arranged *in series* were fully incandesced, affording an ocular demonstration of the presence of the 10,000 volts. A pair of copper wires, with their ends facing one another at a distance of half an inch, were then placed in the circuit, and all lamps were extinguished. The primary current being turned on, the ends of the wires were immediately seen to glow with a brush discharge, which steadily increased in brilliancy until, in about four or five seconds, the circuit was broken by the rupture of the safety fuse. The light at the points did not attain any great degree of brilliancy and bore no resemblance to an arc; the current probably did not exceed three or four amperes.

In connection with the Deptford scheme, it may be interesting to mention that arrangements will be made whereby the 46-feet dynamos may be taken to pieces, to permit of the inspection of the armature, in the space of *one and a-half minute*. For this purpose a special winding engine for separating the field-magnet is provided, as well as a barring engine for moving the armature. We understand that it is intended by this means to make a daily inspection of the machines.

In the development of electrical engineering Australia has hitherto shown itself to be even more behindhand than the mother country; but we have noted of late several encouraging signs of progress there and in New Zealand. In the report of the directors of the Australasian Electric Light Power and Storage Company we find the following sentence, to which we give prominence since it entirely accords with our own impres-

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sions:—"In the meantime it is very evident that a great development of electricity in all its branches is just commencin the [Australasian] colonies, and that . . . remunerative work is to be had for a company strong enough to undertake it."

THE coal gas interest is again showing signs of uneasiness, amounting in some quarters to positive alarm; and on this occasion it may be conceded that their trepidation is not entirely groundless. The Gas Light and Coke Company have promptly followed up the announcement of the Deptford scheme by a reduction of 3d. per thousand cubic feet to all consumers north of the Thames. This means, we believe, a saving of something like £200,000 a year to the community, for which they are wholly indebted to electric lighting. One of the leading organs of the gas interest, judging from the following paragraph, seems already to have lost its senses altogether:—"It is well," says the *Gas and Water Review*, "that our readers should know what is being done. We certainly think that a general conference should be held to consider what course is to be taken in order to ensure that this creeping rival shall at least be subject to some control, and limited to some district." "Limited to some district" is excellent!

WE are very pleased to learn that the suggestion made last week in these columns to the effect that the Submarine Telegraph Companies should undertake to make observations on lightning phenomena, in accordance with the proposals of Dr. OLIVER LODGE for meteorological stations, is not unlikely to bear fruit. What is now required is a detailed plan of operations, including designs for the experimental rod or rods to be erected. During certain times of the year, at such stations as Penang and Singapore, thunderstorms are of daily occurrence, and probably more would be learnt in a few weeks than in as many years in this country.

WE have already expressed a good deal of scepticism as to the alleged process of refining sugar by electricity, over which so many people in Liverpool and Birmingham have lost their heads. (Let us hope, by the bye, that no more serious loss may ensue.) In the first issue of a new monthly journal called *Sugar* there is a paper by Mr. T. L. PATTERSON, F.C.S., in which such meagre information as has been allowed to appear is subjected to critical examination. And meagre as the published details are, enough has been disclosed to furnish a condemnation of the story. Mr. PATTERSON'S indictment amounts briefly to this:—It is stated that the process is dry throughout; but dry sugar is a non-conductor of electricity. Raw sugar consists of cane sugar intermixed with glucose and various foreign ingredients, and it is practically impossible to remove the foreign matter, such as sand, woody fibre, &c., except by solution. It is claimed that the whole of the glucose is converted into cane sugar. The chemical composition of glucose is given by the formula $C_6H_{12}O_6$, while that of sucrose is $C_{12}H_{22}O_{11}$; to turn glucose into sucrose it is therefore necessary to abstract one molecule of water. Notwithstanding the innumerable attempts which have been made to effect this transformation no practical success attended any of the earlier efforts. About two years ago it was, however, said that two French chemists had succeeded in producing a certain amount of sucrose from glucose by electrolysis; but this, of course, was in *solution*; and after all nothing came of it. Moreover, it is impossible to believe that the sucrose if formed could be re-crystallised *in the dry condition*. Lastly, Mr. Patterson examines the per centage analysis which the company has been unwise enough to give to the world, and he is able to demonstrate that if the figures are correct the electrical process must be credited with the production of about 2 per cent. more refined sugar than is contained in the raw material. If this be confirmed we shall be quite willing to admit the invaluable nature of the discovery in spite of all other objections.

WE have been pleased to learn that the Fyfe-Main Electric Lighting and Construction Company are amongst those who are very distinctly feeling the influence of the present revival in electric lighting. We say this with the more emphasis since (and it is perhaps a fact not generally known) none of the original shareholders in this company lost any of the money which they subscribed, the whole of the £60,000 of paid-up capital having been returned in full. In our last issue we somewhat inadvertently referred to this company in the same breath with certain others whose history is of a less fortunate character. It is well known that the company in question have several very successful installations at work in the Fleet-street newspaper offices, including those at the *Daily Telegraph*, the *Standard*, and the *Daily News* offices, whilst some others of the same character are now in hand. We learn also that a new street which is being built at Brixton is to be lit with 40 Fyfe-Main arc lamps. We shall shortly give further details of this installation, which is likely to prove of an interesting character.

THE United Telephone Company have just received from America a switch-board which, when fitted, will be the largest in this country, being capable of accommodating between five and six thousand subscribers. This is now the eleventh multiple board put up by the United Telephone Company, and has been acquired in order to carry out more fully the policy of centralising the exchanges which was initiated some years ago. This step will enable two additional exchanges to be closed. At one time it would have been considered necessary to close the switch-room in order to permit alterations of this kind to be made; but, as a matter of fact, the extensive series of changes which are to be made in the London service are being carried out without the subscribers becoming aware of the fact.

AT Normanton recently we had an opportunity of inspecting the electric pumping plant at St. John's Colliery, which was described in detail in our issue of March 30th. Our readers will recollect that this plant was designed by Messrs. IMMISCH AND Co. It was erected about Christmas last, and has been working since then almost continuously. The duty is about 7,000 gallons per hour raised through a height of nearly 900ft. Messrs. LOCKE AND Co. tell us that no difficulty has been

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experienced with the electrical details. The pump hands have readily learned to adjust the brushes and to carry out the few simple instructions given by the makers. The plant had been indicated on the day before our arrival, and the result showed a slightly better efficiency than that obtained by Mr. Albion Snell when the plant was erected. The ratio between the theoretical value of the water delivered on the surface and the work indicated in the cylinders is about 42 per cent., which is more than double that obtained from the compressed air plant previously in use. We may add that an extensive system of electric haulage is about to be adopted in this colliery. A good deal of the plant is already on the spot, and in a few weeks' time it will probably be in working order.

At a meeting of the Rhondda Valley Colliery Officials' Association, held the other day, Mr. Beith (an electrician who attended to advocate electric traction) was asked, "*In your experience as an electrician* can you tell me whether a smaller or a larger cable gives the least loss?" Another "official" was doubtful whether the locomotive would require the same power on a level as on an incline. The discussion finally resulted in the expression of an opinion that locomotives were not likely to be of much use in mines—apparently on the ground that they might be expected, as a rule, to run off the rails. All this shows that, notwithstanding the enterprise displayed by some few colliery owners, yet a vast amount of educational work still remains to be done before the simplicity, efficiency, and reliability of the electric motor will be properly appreciated in the mining world. As another illustration of this fact we may mention a case which has recently come to our knowledge where a well-known firm offered to lay down a complete electric plant, to keep it running for three months, and if unsatisfactory, to clear it away entirely at their own expense. After the negotiations had proceeded for several months, and very considerable trouble and expense had been incurred, the proposal was finally shelved, and a compressed air plant—costing more money, and, of course, not nearly so efficient—was put in. This is, of course, not by any means a solitary instance of the difficulty of overcoming inertia with which the electric motor has to contend.

Interruption of the Trinidad-Demerara Cable.—We are informed that the cable between Trinidad and Demerara is interrupted.

Venezuelan Telegraphs.—Notice has been received of the suspension of traffic on the land lines between Caracas and La Guayra (Venezuela) and Buenaventura.

Copenhagen.—The large brewery at Karlsberg (Copenhagen) has recently been fitted with a very fine installation, comprising four 120 horse-power steam engines and two 1,000 light dynamos.

Augsburg.—The Augsburg authorities have accepted the proposal of the Allgemeine Electricitäts Gesellschaft, of Berlin, to establish a central lighting station in that town for the general supply of electricity.

Jedburgh.—Messrs. John Hilson and Son, manufacturers, have this week had the electric light introduced into the Cannongate Woollen Mills, at Jedburgh. Messrs. H. F. Joel and Co. were the contractors.

Personal.—Mr. George R. Webb (eldest son of the Secretary to the Society of Telegraph-Engineers) has sailed for Bombay, to take up his appointment as Assistant Telegraph Superintendent of the Great Indian Peninsula Railway.

The Royal Institution.—At the general monthly meeting of the Royal Institution on Monday, November 5, the special thanks of the members were recorded for Mr. L. M. Rate's donation of £50 to the fund for the Promotion of Experimental Research.

The Manchester Jubilee Exhibition.—The report of the Manchester Jubilee Exhibition, which has recently been issued, states that the total number of arc lamps employed was 512, and of incandescent 3,570, burning for 500 hours. The total cost amounted to £9,524. 9s. 10d. There were no failures of any kind.

Immisch's Electric Dog Carts and Launches.—We are pleased to learn that the electric dog cart built by Messrs. Immisch and Co. for the Sultan of Turkey has given great satisfaction. His Majesty has not only decorated Mr. Volk, the representative of the firm, but has given orders for another dog cart and an electric launch.

The Telephone in Hampshire.—The West of England and South Wales Telephone Company have now settled all preliminary details for the extension of the telephone from Portsmouth to Gosport, Fareham, Winchester, Southampton, and Bournemouth, so that the work will very shortly be taken in hand. An exchange will presently be opened in Winchester.

Gosport.—The scheme of the British Tramways and General Syndicate for running an electric tramway between Gosport, Alverstoke and Bury Cross was considered at a recent meeting of the Roads and Works Committee of the Alverstoke Local Board. The committee unanimously resolved to recommend the scheme for the sanction of the Local Board. The line will be of the three-foot gauge, and accumulators are to be used.

The Northern District Telephone Company.—The Northern District Telephone Company have opened exchanges at Wallsend-on-Tyne and Linthorpe. Exchanges will also shortly be opened in Alnwick, Berwick, Redcar, Saltburn, and Jesmond. The trunk line to Redcar and Saltburn is already constructed, and messages are daily sent from these towns over the whole of the company's system, in some cases over a distance of 90 miles.

Gillingham.—At the last meeting of the Gillingham Local Board, Mr. Mackay drew attention to the article in *The Electrician* on the new works at Deptford, with a view to eliciting information as to the terms existing between the board and the gas company. It was stated that in the event of the board being desirous of terminating their contract with the gas company no notice of such termination would be requisite.

The Lighting of the Mansion House.—At the last meeting of the City Council Mr. Judd moved "That it be referred to the General Purposes Committee to consider the best means of lighting the Mansion House by the electric light, to obtain tenders and estimates for the necessary works, and to submit them to this Court, and that for this purpose the committee be authorised to expend a sum not exceeding twenty guineas." This was agreed to.

The Kensington Vestry at Eastbourne.—The members, officials, and medical staff of the Kensington Vestry visited Eastbourne on Monday last to inspect and report upon the working of the electric light, now adopted by the Corporation for the sea-front and municipal buildings. The Mayor entertained the deputation at a public luncheon, where the enterprise of Eastbourne was highly praised. Over 1,700 electric lights are now in use in that town.

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Street Lighting in London.—At a meeting of the Committee of Works of the St. George's Vestry a letter was read from the Vestry of St. James's relating to certain proposed alterations in the gas lighting of those streets which are under the joint control of these vestries. A motion was, however, carried to the effect that, in view of the recent great advances in electric lighting, the present is an inopportune time to make any alterations in the street lamps.

Dartmouth.—The West of England and South Wales Telephone Company are about to extend the telephone system which centres at Torquay to Brixham and Dartmouth. In the case of the latter town, the wire will be carried over the River Dart at a considerable elevation, so as not to interfere with the navigation, at a point where the stream is over a third of a mile in width. Newton Abbot, Totnes, St. Marychurch, and Paignton are already connected with Torquay.

The Regulation of Dynamos.—In a recent number of the *Electrotechnische Zeitschrift* there appears an article by M. Paul Müller describing a method of regulating dynamos by means of a movable core contained within hollow field-magnets. As a translation of this article has been published by one of our contemporaries it may be as well to say that, whatever may be the practical value of the device, it is already public property, having been described in a very early patent of Lontin.

Machinery and Tool Catalogue.—We have received from Messrs. Churchill and Co., of 21, Cross-street, Finsbury, a handsomely got-up catalogue of American machinery and tools, comprising all kinds of lathes, wood-working machines, twist-drills, lathe and drill chucks, milling machines, gauges, callipers, sight-feed lubricators, blowers, fans, exhausters, indicators and valves, &c., &c. Many of our readers will find it worth while to get a copy of this catalogue, which contains several novelties which have been specially selected for the English market.

Toulouse.—Owing to the enterprise of the Comte de Chanteau, Toulouse will shortly possess a fine central lighting station. The plant will comprise 8,330 horse-power turbines, 4,330 horse-power steam-engines, and the necessary number of boilers. Each turbine and steam-engine will drive direct a couple of continuous-current dynamos, each absorbing 160 horse-power, and running at 250 revolutions a minute. The current generated by the hydraulic plant will be utilised by day for electrolytic purposes. The firms of A. Pinguely, of Lyons, and P. Blanchot and Co., of Vevey, are the contractors.

Brussels Exhibition Awards.—The jury of the Brussels Exhibition have just made their awards, and we are pleased to learn that the Electrical Power Storage Company has been awarded a gold medal. All the electrical firms which have taken part in the lighting of the exhibition have been given *diplômes d'honneur*. In addition to this gold medals have been awarded to MM. Mourlon Frères, Pieper, Bouckaert, as well as to the Phœnix and Industrielle Companies. Silver medals have been obtained by MM. Schubart, Raikem, Van der Plassche, and bronze medals by MM. Belot, Ehlis, Hauman-Devos, Ernhardt, and many others. The distribution of prizes will take place on the 11th inst., the day the exhibition closes. The ceremony will be presided over by the Comte de Flandre.

Electric Traction at Geelong.—At a special meeting of the committee of the Geelong and District Electric Tramway Conference, held recently for the purpose of considering the report of the sub-committee in respect to the tender of the Electric Lighting and Property Investment Company, the tender submitted was for the right to run tramways in Geelong, Newtown and Chilwell, Geelong West, and South Barwon, offering 25 per cent. of the profits after a first charge of 8 per cent. per annum had been reserved for the benefit of the shareholders, and also to give an annual subsidy, the minimum of which should be £100, to the councils. The tender was accompanied by a cheque for £250. There being a difference of opinion at the conference then held, the matter was referred to a sub-committee, who now brought up a report. After some discussion it was resolved that the tender received, subject to ratification by the respective councils, should be accepted.

Electricity and Mining.—At the meeting of the Midland Institute of Mining Engineers, held at Barnsley last week, Mr. Rhodes, the newly-elected President, delivered his inaugural address. Amongst other topics he spoke of the applications of electricity to mining, and said that as a motive power it was pushing itself to the front, and it was far from improbable that, as it became better known and appreciated, it would take the place of every other motive power in use for mining purposes, chiefly because of the ease with which power could be conveyed long distances from one station. In future the colliery and mining engineer would also have to be an electrician. He hoped the question would be dealt with in Papers to be read before the Institute at an early date. For illuminating purposes the question of a portable electric safety lamp was solved, save for the heavy first cost, and he was sanguine that before long the cost would be reduced so as to bring them within the reach of every colliery.

The Action of Electricity on the Vesicles of Condensed Water.—In the *Archives des Sciences Physiques et Naturelles* M. J. L. Soret recently described the following interesting experiment:—In a dark room a platinum cup containing water is placed on a metal support, which is connected with one pole of a Topler machine. Above this cup a metal point is placed which is connected to the other pole of the machine. A Bunsen burner boils the water in the cup, which is powerfully illuminated by the projection of a large pencil of the electric light. As long as the Topler machine is at rest the vapour vesicles ascend in the ordinary way; but as soon as the machine is at work the action of electricity on the vapour is manifested in a most striking manner. For a certain distance from the point to the surface of the water the clouds collect and whirl along the edge of the cup; under the influence of the electric light they look to a certain extent like flames. If the point is brought a little nearer the water the vapour disappears completely, although the water commences to boil briskly.

Society of Arts.—The One Hundred and Thirty-fifth Session will commence on Wednesday, the 21st November, with an opening address by the Duke of Abercorn, C.B., Chairman of the Council. Previous to Christmas there will be four ordinary meetings, in addition to the opening meeting. At the first ordinary meeting of the Society a Paper will be read by Colonel Gouraud on "The Phonograph." This will be followed by one by Mr. Henry Edmunds on "The Graphophone." At the other two meetings to be held before Christmas the Papers will be by Mr. W. H. Deering on "Explosives," and by Mr. W. J. Dibdin on "Standards of Light." Among the Papers announced for the latter part of the Session may be mentioned—"Manufacture of Sèvres Porcelain," by Mr. E. Garnier (Director of the Sèvres Manufactory); "The Forth Bridge," by Mr. Benjamin Baker; "The Channel Tunnel," by Colonel Hozier; and "Secondary Batteries," by Mr. W. H. Preece, F.R.S. The first course of Cantor Lectures will be by Captain W. de W. Abney, C.B., F.R.S., on "Light and Colour;" the other lecturers will be Mr. Alan S. Cole, Mr. W. J. Linton, Mr. Walter Crane, Mr. C. V. Boys, F.R.S., Mr. H. Graham Harris. The Juvenile Lectures, at Christmas, will be given by Prof. Henry E. Armstrong, Ph.D., F.R.S., the subject being a chemical one.

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Strange Lightning Phenomena at Geneva.—During a terrible storm which burst over Geneva on the 2nd October several interesting meteorological phenomena were observed, and amongst others a globular discharge which took place at Lancy, near Geneva. The house struck was in an isolated position, and closely surrounded by high trees, the branches of one of the highest almost touching the roof. The building was provided with two lightning-conductors. M. R—— was sitting with his clerk in a room on the first floor, the door, which led into a passage, being wide open. Suddenly a ball of fire about 3 centimetres diameter appeared in the doorway at a height of nearly 1 metre from the floor, and burst with a noise like that of a pistol-shot. Nearly simultaneously M. R—— saw through the window a shower of "golden spangles." The lightning-guards of the telephones in the room and at the vaccination institution 500 metres off, which were in direct communication, were both slightly burnt. The bell and telephone wires were not injured inside the house, but the outside wires of both were damaged. For a distance of about 20 metres the telephone wires, at the point where they joined the village telegraph posts, were melted, and the insulators were blackened. A gutta-percha covered telegraph wire close by was destroyed for the length of a metre. Neither the roof of the house nor the surrounding trees were touched.

Berlin.—The work done by the Edison Company in this town is so good, says *Industries*, that the public and the municipal authorities have perfect confidence in their ability to extend their central station work still further, and a concession has been given to this company for the establishment of two new stations—one in the centre of the town and the other in the south-east quarter, where most of the engineering works and other factories are situated. Both stations must be ready within two years, and each must be able to supply current for 6,000 glow lamps burning simultaneously. The station in the centre of the town will eventually be increased to a capacity of 24,000 lamps, and the other station will be increased to 12,000 lamps, the annual increase to be not less than 6,000 and 3,000 lamps respectively. All the cables required in connection with these stations must be in position by the end of 1892, and the supply of current within both districts will be compulsory, provided the customer is willing to take the light for at least one year. The network of cables to be laid down in connection with these stations is very complete, and practically comprises all the streets of the respective districts, some small and unimportant side streets alone excepted. In view of this extension of their business, the Edison Company propose to increase their share capital at present by £150,000, and later on by £300,000. The electric light installation in the Monopol Hotel of this town, which comprises 1,000 lamps, will shortly be in action. The work has been executed by the Berliner Maschinenbau-Actiengesellschaft, under the superintendence of Herr Beringer. The current is supplied by two 80 horse-power dynamos, each direct coupled to a twin engine. The dynamos are of the eight-pole disc type, and are compound wound. Steam is suppliedby two Babcock and Wilcox boilers, having collectively a heating surface of 2,400 square feet.

Hastings.—At the last meeting of the Hastings Town Council the Public Lighting Committee recommended that the existing contract with the Electric Light Company, for the lighting of the front, from the Queen's Hotel to Warrior-square, by means of fifteen 2,000 nominal candle-power arc lamps for the sum of £450 per annum, which expires on the 26th of November, be renewed for another year, subject to the company substituting lamps of the new pattern where not already done.—Councillor Jenner said the Electric Light Company had consented to erect new lamps, which had proved a great advantage, and did not throw shadows across the road or pavement. The electric light had taken such a hold on the people that it would be difficult for them to shake it off. It was a very beautiful light, he admitted, but also a very expensive one.—Councillor Revill said he had been a consistent supporter of the electric light from the commencement. He believed the light had been the means of attracting people to the town. He hoped that in the near future the light would be cheaper. He had nothing to say against the gas company, but he contended there was plenty of work to do, not only for the gas company but the electric company also.—Councillor Stanger complained of the expense of the electric light.—Councillor Duke said the difference between lighting with the Whitehall lamps and the present system had been calculated, and it was found there was a difference of only £150 against electricity. Visitors and others would agree that the £150 was well laid out.—Councillor Hutchings opposed the adoption of the report. He thought the Whitehall lamps were sufficient for the purpose, and if they could save £150, why should they not? In deference to his pledge to economy he felt bound to oppose the electric light when they could obtain efficient lighting for £150 less.—Alderman Bradnam contended that the electric light was a benefit to the town at large; but if at the end of 12 months they preferred to relinquish it they had the power.—The motion was carried.

The Town Council and Electric Lighting in Birmingham.—The following is the most important portion of the report which will be submitted to the Birmingham Town Council by the Committee to which the electric lighting question was referred: "On the 23rd October your committee had an interview with Messrs. Chamberlain and Hookham, accompanied by their solicitor, Mr. Pinsent, and pointed out various objections to the draft provisional order, when, after considerable discussion, the promoters decided to withdraw the order in the form originally presented, and to substitute an amended order, with the view of meeting certain of the objections raised by your committee. On the 2nd November the town clerk received an amended form of order, which more closely followed the model form approved of by the Board of Trade, and known as 'The Chelsea Order, 1886.' By this order it is proposed, within three years from the date of the same, to lay down distributing mains in a considerable area in the centre of the town, and to include the whole borough within the provisions of the order for the purposes of future extension. It is quite obvious that your committee will require considerably more time before they can present any definite recommendation upon this subject, and it becomes a matter worthy of consideration whether the better plan will not be to decline to consent to an order at present, with a view to the whole question of electric lighting under the provisions of the Act of 1888 being carefully inquired into on behalf of the Corporation. Another reason for delay is that your committee have now before them several applications from other persons for permission to place overhead wires across the streets for the transmission of electricity; and it appears to your committee that the subject of electrical light and power distribution demands more time and attention than it has been possible to give it up to the present date. The question has been again raised as to the propriety of the Corporation themselves obtaining an Act or provisional order for the supply of electricity within the borough, and it becomes necessary to ask for further time for consideration before arriving at any conclusion upon so important a subject. Your committee, therefore, recommend that the consideration of the Birmingham Electric Light and Power Order be deferred for the present."

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 815, Vol. XXI.)

Henry was followed in his researches on Leyden jar discharges and the currents induced thereby in adjacent circuits by Abria, Marianini, Reiss, and Matteucci. Matteucci endeavoured to determine the direction of the induced discharges by employing a process founded upon the experiment of the pierced card, in which the hole made by the spark on a piece of paper or a card is always nearer to the negative electrode. By means of this process, combined with the employment of the galvanometer, Matteucci considered that the inductive discharges are determined by the following law:—If the inducing and induced circuit are both closed, the induced discharge is in the *opposite* direction to the inducing discharge. If, however, the induced circuit is interrupted at any point so that there is a spark, the induced discharge is in the *same* direction as the inducing. Abandoning these methods above described, M. Verdet* employed another, which depends upon the *polarisation of electrodes* in dilute sulphuric acid.

From more recent knowledge we may state the facts with regard to the action of alternate currents upon a dilute sulphuric acid voltameter as follows†:—

If a current of electricity consisting of alternate short fluxes of current of opposite sign is passed through a voltameter having platinum electrodes, and if these electrodes are large, there is no visible decomposition, but if the electrodes be reduced in size below a certain limit visible decomposition begins. For every current there is a certain size of electrode, below which gas is not visibly evolved, and for every given size of electrode there is a current below which gas is not apparently liberated. When the conditions are suitable for the liberation of gas the gases collected at both electrodes have the same composition. If the quantities of electricity passing in each alternate and oppositely directed flux are equal, then the electrodes are not sensibly polarised. If, however, the quantities are not equal, then there is, on the whole, a greater flow of current in one direction than the other, and the electrodes exhibit the state known as polarisation, and yield a reverse current when connected with the galvanometer. Verdet, in his experiments, made use of flat spirals, the wires of which were insulated from each other with great care by silk and a layer of gum-lac varnish. The primary spiral was made of copper wire $\frac{3}{4}$ths of an inch in diameter and 92 feet in length, forming 24 spirals. The secondary circuit consisted of three spirals of wire $\frac{1}{10}$th of an inch in diameter and 157 feet in length, making 95 turns. The inducing discharge was supplied from a Leyden jar battery of 9 large jars. The induced discharge was sent through a voltameter having small platinum electrodes, and which could be connected with a delicate galvanometer for detecting polarisation of the electrodes immediately after the discharge. M. Verdet's experiments led him to recognise that when the induced circuit is continuous, and not interrupted anywhere except by the insertion of the voltameter, no traces of polarisation are obtained except by very powerful discharges. This indicates that the induced discharge consists of a double current of two oppositely directed and equal quantities of electricity. In the case of very powerful discharges there was a slight galvanometric deflection, indicating a preponderating secondary discharge in the *same* direction as the primary. If the induced or secondary circuit is interrupted at one point, so that the discharge has to pass as a spark at that place, then very perceptible polarisation of the electrodes presents itself, and the direction of this is such as to indicate a predominant induced current passing in the *same* direction as the primary.

To sum up. It follows from all the numerous researches on induced discharges that this is a very complex phenomenon, and is influenced by a large number of conditional circumstances, and also by the very mode employed for determining it. It may be, however, taken as proved that an induced discharge, produced either as a secondary discharge by a transitory primary, such as the discharge from a Leyden jar, or a tertiary current produced by induction by a secondary current of very brief duration, is in its simplest form a wave of electric current, consisting of two short fluxes or currents in opposite directions, and succeeding each other immediately. This Poggendorff* holds to be shown by the action of such tertiary or higher order currents on a galvanometer. If these currents are led through a galvanometer of which the arrangement is such that the magnetic axis of the needle is accurately at right angles to the direction of the magnetic axis of the coil, then no deflection of the needle is observed, or at most a very slight one. If, however, the needle makes an angle with the plane of the coils, then these induction currents cause a deviation of the needle. This effect (*der doppelsinnigen Ablenkung*) arises from the fact that the magnetism of the needle is not rigid, and that the alternate twisting couples to which the needle is subjected are not equal, by reason of the fact that one of the halves of the complete induced current—say the direct half—increases the magnetic moment of the needle, and hence increases slightly the deflecting couple in the direction tending to increase the deviation of the needle; the other half—say the inverse part of the induced current—tends to reduce the moment of the needle, and hence to subject it to a smaller reverse couple. Hence it follows that, if discharges of equal quantity and opposite sign succeed each other through a galvanometer when the needle is accurately in the plane of the coils, little or no deviation is observed; but if the coils are turned so that the needle makes an angle with them, then these alternate currents will affect the needle and increase the angle of deflection.

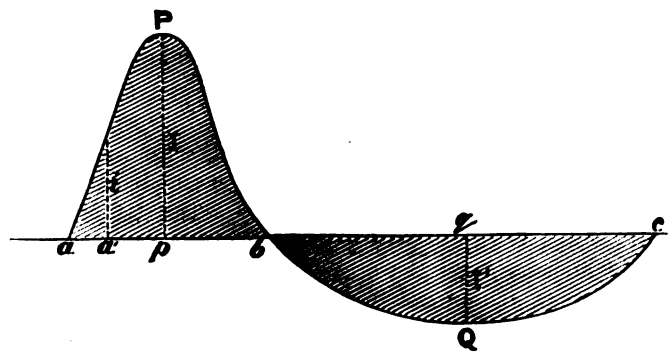

FIG. 9.

This behaviour towards a galvanometer, and the action on a voltameter of liberating mixed gases of equal composition at each pole prove that each induced current of the third and higher order consists of two oppositely directed discharges, produced by the operation of two successive electromotive impulses of opposite sign and very brief duration acting upon the circuit. The quantities of these discharges are equal; but the durations are different, and hence the maximum value of the current strength during the opposite discharges may be very different. This may be illustrated graphically thus:—

Let the curve a P b Q c (Fig. 9) be a current curve representing two waves of current of opposite sign succeeding each other. Let the horizontal line $a c$ be a time line, and vertical ordinates represent instantaneous current strengths. Then the areas (shaded) will represent the *quantity* in each discharge. Let these shaded areas be equal, then the diagram represents two discharges of equal quantity succeeding each other in opposite directions, but having very different maximum current strengths I and I'. The duration of the first discharge is represented by $a b$, and that of the second by $b c$. This diagram represents, then, what we find in the simplest case of tertiary current. If the instantaneous value of the current at any time is called i, then the whole quantity of the discharge will be represented by the shaded area and by the integral $\int i\,dt$ between proper limits.

* Verdet, *Ann. de Chem. et de Phys.* [3] Vol. XXIX., p. 501, 1850.

† *See* a Paper by MM. Maneuvrier and J. Chappuis, abstracted in the *Electrician*, June 29, 1888, Vol. XXI., p. 237.

* Poggendorff, *Pogg. Ann.*, Bd. XLV., p. 353, 1838

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We may classify the effects of induced discharges or currents in the following way :—

(1) Those effects dependent upon $\int i\,dt$, or upon the whole quantity of the discharge. These are the *galvanometric* and the *electro-chemical* effects. If a discharge is passed through a galvanometer, the duration of which is very small compared with the time of free oscillation of the needle, the galvanometer needle experiences a "throw" such that the sine of half the angle of deflection is proportional to the whole quantity of the discharge. Also in a voltameter, by Faraday's law, the whole quantity of the electrolyte broken up is proportional to the quantity of electricity which has pass through it.

(2) Those effects dependent upon $\int i^2\,dt$, or upon the average of the square of the strength of the current at every instant during the discharge. These are the *heating* and the *electro-dynamic* effects. By Joule's law at every instant the rate of dissipation of energy is proportional to the square of the current strength, and hence the whole heat generated by the discharge is proportional to the integral above. Similarly, if the discharge passes through a circuit, part of which is movable and can react upon a fixed part, so that attraction or repulsion may take place between them, the force is dependent at any instant on the square of the current strength, and hence the whole effect or average force upon the same integral.

(3) We have, lastly, effects dependent chiefly upon the maximum ordinate I, or upon the rate of change of the current—that is, upon the steepness of the slope of the current curve. These are the *physiological*, *telephonic*, *luminous*, and *magnetic*.

The physiological effect of a discharge in giving a shock appears to depend in great part upon the suddenness with which the maximum current strength is reached. Of two discharges which reached equal maxima, that which arrived at it in the shortest time would be the most effective in producing shocks. The value of the maximum current strength is also important. Two induced currents of equal quantity but different duration cause a greater shock in proportion to their lesser duration. The telephone in this respect resembles the animal body. It is affected more by the rate of change of the current strength than by the absolute current strength at any instant.

The *magnetic* effect depends, as has been shown by Lord Rayleigh,* upon the maximum current strength during the discharge, or upon the initial current strength, in those cases in which the current dies gradually away. In the two Papers referred to below it is shown by direct experiment that, since the time required for the permanent magnetisation of steel is small compared with the duration of induced currents generally, the amount of acquired magnetism depends essentially on the initial or maximum current strength during a transitory current, without regard to the time for which it lasts. It is, then, not difficult to understand that the effort to settle by experiment with a magnetising coil the direction of induced discharges may lead to very conflicting results, and, in any case, it is hardly competent to do more than indicate the direction in which the maximum current flow takes place during the discharge.

The *spark* effects are also included in this category. The air or other dielectric is broken down when the difference of potentials between the two discharging points reaches a certain magnitude, and in the case of a varying electric pressure the question whether a spark will pass or not is evidently determined by the maximum magnitude of that quantity.†

It is evident from the above considerations that the complete analysis of the effects and phenomena of induced currents of the higher orders, and of those of secondary currents due to discharges from condensers, requires a knowledge of the *form* of the current curve in each case.

(To be continued.)

* See *Phil. Mag.*, Ser. 4, Vol. XXXVIII., 1869, p. 8: The Hon. J. W. Strutt, "On some Electromagnetic Phenomena." Also *Phil. Mag.*, Ser. 4, Vol. XXXIX., 1870, p. 431.

† *See* Bertin, "Notes on Electrodynamic Induction," *Ann. de Chimie*, 4th Ser., Vol. XXII., April, 1871, p. 486.

LIGHTNING CONDUCTORS.—II.

BY DR. OLIVER LODGE.

Record of Experiments on the Alternative Path.

As explained last week, I proceed to record the series of experiments I have made on the E.M.F. needed to drive a given discharge through a conductor. These experiments are mixed up in my note-book with a number of others made with slightly different objects, but it will be clearer if I pick out all those of one kind first, and attend to the others afterwards.

I begin with some early experiments—the first tried by me—when the arrangements for measuring spark length were comparatively imperfect (a graduated wedge was inserted between the knobs of the discharger), and when the essential conditions were less understood. They are not so immediately available for testing theory, but there are some instructive points about them nevertheless.

Early Experiments. February, 1888.

7. A copper wire, about No. 22 B.W.G., and an iron wire, about No. 20, were stretched round the lecture theatre (a length of some 35 yards), being suspended by silk threads from four vertical posts a good way off every wall. A large condenser, consisting of 16 pairs of 11in. square tinfoils separated by double thicknesses of window glass each about $\frac{1}{10}$in. thick, the whole soaked and embedded in a mass of paraffin and enclosed in a teak box, was used. [The capacity of this condenser was subsequently determined as ·028 microfarad.]

The condenser was charged through the long wire, and a choice was offered the discharge, so that it might go either round the wire or leap an air-gap, as it chose.

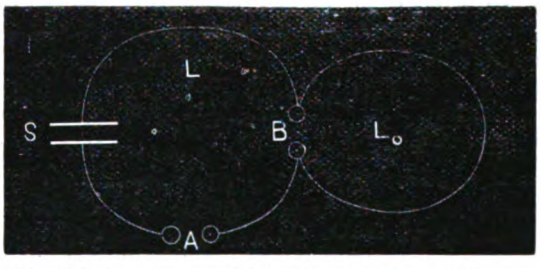

FIG. 2.—This figure is repeated for the convenience of the reader.

A are the ordinary terminal knobs of the machine where the spark occurs; B is the discharge interval alternative to the wire or to other resistance. The spark length B was adjusted so that it was an off chance whether the discharge chose it or the wire. It was noticed that when the discharge chose B the A spark was strong, but when the discharge chose the wire the A spark was weak. The difference appeared to be only in the noise or suddenness of the spark, for when a Riess's electro-thermometer was inserted in the circuit it indicated about the same in either case. A number of observations were made with this energy-measuring arrangement, but I appear to have no record of them.

The following are the spark length readings :—

Critical B Spark length.	*Choice open being,*
·60 inch	... Iron wire round room.
·61 ,,	... Copper ditto.
·64 ,,	... Both wires in series (currents in same sense).
·60 ,,	... ditto. (currents in opposite sense).
·97 ,,	... A 6-inch capillary glass tube full of tap water.
·74 ,,	... The same tube full of dilute acid.
·02 ,,	... A short copper wire 2ft. long.
·075 ,,	... Very thick iron rod a yard long.
·075 ,,	... Very thick brass rod a yard long.
·11 ,,	... 18 inches of thin brass wire.
·11 ,,	... The same taken once through a large ring of iron wire.
·16 ,,	... Ditto.

This was the first experiment that distinctly suggested that the ordinary magnetic properties of iron were suspended under these circumstances. The iron ring was in the position of the iron core of a transformer, and yet it exerted no appreciable

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effect on the impedance of the wire round it.* The experiment was made because the previous experiments had indicated how equal iron and copper seemed, showing none of the expected great difference between them.

The readings in these experiments are not to be supposed at all accurate, and the second place of decimals means very little. No doubt the actual *readings* are taken correctly enough, but we had as yet by no means hit on the best procedure for determining the critical B spark with any nicety, and in this first set of experiments the length of the A spark is not recorded.

8. A set of observations was now taken with the object of seeing what effect the length of the A spark had upon B under these circumstances.

Experiments on the Connection between Lengths of A and B Sparks.

(The alternative path being the iron wire round the room all the time.)

A Spark length. inch.	Critical B Spark length. inch.	$\frac{B}{A}$
·12	·095	·8
·225	·22	·98
·28	·30	1·07
·31	·35	1·13
·36	·405	1·10
·40	·48	1·20
·46	·575	1·25
·537	·648	1·21
·578	·726	1·26
·587	·726	1·24
·587	·744	1·27

The ratio of B to A thus increases with the energy of the discharge, but seems to approach a limit.

9. Now arrange a gallon Leyden jar (of capacity, as subsequently determined, 55 metres electrostatic units, or ·006 microfarad) as a lateral appendage to the B terminals, in the same way as the condenser of an induction coil is a lateral appendage to the contact breaker; the idea being that it would reduce the liability to spark across B, and help the discharge to choose the wire path.

Alternative path.	A readings. inch.	Critical B readings. inch.	$\frac{B}{A}$
Iron wire round room	·533	·498	·92
" "	·428	·397	·93
" "	·28	·267	·95
" "	·145	·123	·85
Copper wire round room	·145	·123	·85

10. The jar was now removed and the experiments continued.

Wire round room	·295	·339	1·15
Capillary tube containing acid	·240, ·255, ·266	·339	1·41, 1·37, 1·27
Acid tube and wire in parallel	·296	·339	1·15
Same with wire cut in middle, and ends separated a few inches†	·286	·339	1·18
Wire and acid tube in series; acid tube in middle of wire, filling up gap	·282	·339	1·2
Ditto with gap mended; acid tube at one end of wire	·274	·339	1·2
Ditto acid tube at other end	·266	·339	1·27
Acid tube only, the wire being included in the rest of the circuit	·266	·339	1·27

When the acid tube was the alternative path, and the B knobs so far apart that the discharge was obliged to choose it, the A spark was very weak, being reduced to a quiet spit, which could be analysed by a slowly rotating mirror into several detached sparks.

11. The resistance of the capillary acid tube so frequently mentioned was afterwards estimated as follows:

The tube full of mercury	·437 ohm.
The tube full of zinc sulphate solution, of strength $\frac{ZnSO_4, 5H_2O}{20}$ in 100 cc, with zinc electrodes. No difference on reversing battery	177,000 ohms.
The tube full of extremely dilute acid as generally used	from $\frac{1}{4}$ to $\frac{1}{2}$ a megohm.

* This led on to a series of experiments on the effect of iron cores, and on the magnetisation of steel and iron by a discharge.

† The brushes and vigorous disturbances subsequently seen at this gap led on to a series of experiments on "the recoil kick."

Experiments with a Smaller Condenser.

12. Instead of the large condenser, I now tried either a pint or a gallon Leyden jar (capacity ·0016 or ·0061 microfarad) and got much the same results. The jar often overflowed its edge and self-discharged, but a spark still occurred at B when this happened, though not at A.* Hence, an overflow path was provided, at C (Fig. 7); and sparks at B and C could be got, but not at A; or at A and B and not at C; or at C only.

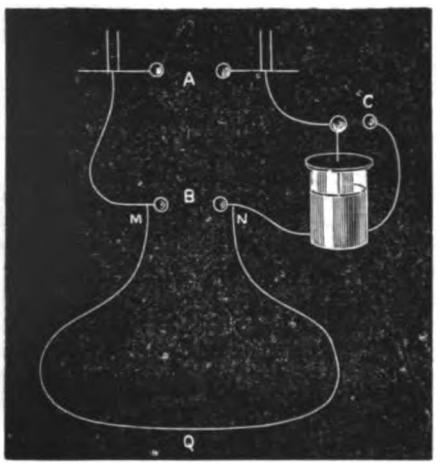

Fig. 7.

It was found that connecting the knob of the jar to earth, the jar itself being insulated, increased the strength of the B sparks very much, and made them easier to get. Evidently the wire was acting as one coat of a condenser, the wall being the other coat.

13. Putting acid resistance into the circuit at M or at N weakens but does not stop the B sparks, and it has the same effect at M as at N. But inserting resistance at Q does not weaken the B spark perceptibly; neither does cutting the wire there, only of course, in order to permit the charging of the jar, the B gap has to be bridged by some very imperfect conductor, this shunt high resistance having no appreciable effect upon the B spark.

14. The jar was now discarded, and the wire alone used, as in Fig. 8. The sparks occurred at B perfectly well,† and were much the same whether the wire was cut at Q or not.

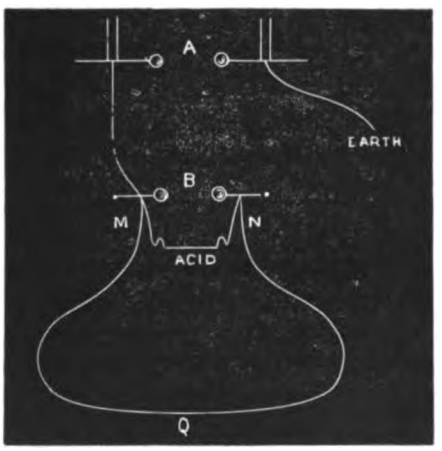

Fig. 8.

After a great number of experiments in various other directions, "overflow," "recoil kick," "liability to be struck," "side flash," "gauze house," "bye path," &c., some more experiments on alternative path were done, and to these we now proceed.

Further Experiments with Various Long Leads, March, 1888.

15. I had now arranged round the theatre a couple of very stout wires, almost rods, supported by silk ribbon, each about

* This led to a series of experiments on "overflow."

† This led to a series of experiments on the "surging circuit."

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27 metres long, one of No. 1 iron, the other of No. 1 copper; besides these there were a couple of leads of ordinary thickness, each about 30 metres long, viz., No. 18 iron, No. 19 copper, and one lead of fine iron wire, No. 27, also 30 metres in length.

The resistance of these leads measured in the ordinary way, Carey Foster's method being used for the short ones, was

Resistance of No. 1 copper	·0254	ohm.
,, ,, 1 iron	·0881	,,
,, ,, 19 copper	2·72	,,
,, ,, 18 iron	3·55	,,
,, ,, 27 ,,	33·3	,,

The copper is evidently of shocking bad electrical quality, but so is most of all of what one buys at an ordinary metal merchant's. I must say, however, that the Birmingham wire gauge nomenclature is never intended to be anything more than roughly descriptive of the wire. When one wants to know its diameter really, of course one measures it.

Sectional radius of the No. 1 copper lead	·37	centimetre.
,, ,, ,, 1 iron	·355	,,
,, ,, ,, 19 copper	·0425	,,
,, ,, ,, 18 iron	·060	,,
,, ,, ,, 27 ,,	·0175	,,

Each of the two thick leads formed a rough rectangle about 840 centimetres by 515 centimetres, the entire length of each wire being 2,710 centimetres. The three thinner leads formed rough rectangles of 840 by 675 centimetres, and the length of each of these was 3,030 centimetres.

These dimensions are necessary to be known, in order that we may hereafter calculate their coefficient of self-induction.

The static electric capacity of the leads was determined roughly by charging them with 144 small cells, discharging through a ballistic, and comparing the kick with that obtained from a small jar of known capacity treated in the same way.

The results (quite rough) are

Electrostatic capacity of either thick lead	5	metres.
,, ,, either medium lead	3½	,,
,, ,, thinnest lead	3	,,

16. For the alternative path experiment with these leads, arrangement Fig. 5 was adopted, two gallon jars being used; the A knobs being those of the machine, while the B knobs belonged to a universal discharger. The only divergence from the figure was that the ends of the alternative path were connected direct to the outer coats of the jars instead of quite directly to the B knobs. The length of the A spark was kept at 1in., the B knobs were adjusted till their spark just began to go.

Alternative Path.	*Length of B Spark.*
No. 1 copper round room	1·43 inch.
No. 27 iron ,,	1·03 ,,
No. 1 iron ,,	1·08 ,,
No. 19 copper ,,	1·34 ,,
No. 18 iron ,,	1·08 ,,

At the rooms of the Society of Arts these same, or very similar, leads were rigged up, and the experiment repeated, with much the same result. But instead of going round the room the leads were only taken to the end of the room and back, with about 3 yards interval between going and return wire, and the circuits were not arranged one over the other, but all in the same horizontal plane, side by side.

Experiments to Determine the Effect of Self Induction.

17. To help study how much of the effect was really due to self induction I procured a piece of thick stranded double wire cable, each wire being thickly covered in gutta percha, and then the two enclosed in a gutta percha sheath. The ends could be joined in various ways, so as to put the wires in series with the currents going in the same direction, *i.e.*, with a maximum of self induction, or in series with them going opposite ways, so as to have a minimum of self induction ("anti-inductively," so to speak), or in parallel, or in any other way.

The length of the bit of cable was 770 centimetres, and it was arranged to form a rude circle. The ordinary resistances of its wires were ·0608 and ·0586 ohm respectively.

Keeping exactly the same arrangement as before, with the A spark still 1in., the experiments were as follows:—

Alternative Path.	*Length of B Spark.*
The two gutta-percha-covered wires in series, so as to enclose max. area	1·77
The two wires in series, currents enclosing min. area	·91
The two wires in parallel	·91
One wire alone	·91
One wire alone, the other having its ends joined, so as to form a closed secondary	·79

18. A number of experiments were now made with this bit of cable, and with a great thick No. 1 copper open spiral, by inserting large masses of iron, bundles of iron wire, iron bars and rings, into their contour, to see what difference the iron made. So far as one could tell it never made any. To take definite readings, therefore, I got my assistant to make an induction spiral of tinfoil, consisting of a strip of tinfoil 3 inches wide and 21 feet long, wrapped round a glass tube with sufficient insulation between the turns. Also an anti-induction tinfoil zigzag with the same length of tinfoil.

The resistances of these were ·614 ohm for the spiral and ·708 ohm for the zigzag.

The length of the spark A being ·73 inch, the following are the readings taken:—

Alternative Path.	*B Spark.*
Tinfoil zigzag joined up to outer coats of jars by two leads, each a couple of feet of No. 12 copper wire	·23 inch.
Tinfoil spiral ditto ditto	·64 ,,
Spiral with iron wire bundle inserted in its tube	·64 ,,
Leads only (the two No. 12 wires)	·21 ,,
No path at all	1·11 ,,
Zigzag connected direct to jar, without leads	·06 ,,
Spiral ditto ditto	·64 ,,
Spiral with iron bundle inside	·64 ,,

Calculation of Self Induction of Long Leads.

19. The long leads round the room really enclose rude rectangles; but inasmuch as I do not know how to calculate the self-induction for a nearly square rectangle, and inasmuch as bending them out into a circle *of the same perimeter* would certainly not have affected their self-induction much, I reckon it by the formula (8) given last time, assuming that the depth to which the currents penetrate into the substance of the conductor is certainly small.

Using the dimension of these leads as previously given, one thus reckons in electromagnetic units,

Self induction of either No. 1 lead	390 metres.
,, ,, ,, 18 ,,	550 ,,
,, ,, ,, 19 ,,	570 ,,
,, ,, ,, 27 ,,	630 ,,

All this time it had not struck me that it was important to specially know the particulars of the part of the circuit containing the jars, and they were accordingly connected up to the machine by wires in a very ordinary manner; but as far as I can estimate the self-induction of this part of the circuit now I should say it was between 40 and 60 metres usually.

(To be continued.)

Development of Telephone Communication in Nottingham.

On Monday last the National Telephone Company opened an extension of their system at Nottingham. Hitherto the towns in telephonic communication with the centre of the lace trade have been Long Eaton, Ilkeston and Loughborough; but Derby and Birmingham have now been added, a trunk wire running through Long Eaton, Derby, Burton-on-Trent, and Lichfield to Birmingham having been opened. A trunk wire will be laid on to Coventry, from which place a connection will be made with the South of England Company's wires, and a further new wire to Sheffield will open up not only Yorkshire but the extensive district of the Lancashire and Cheshire Telephone Company.

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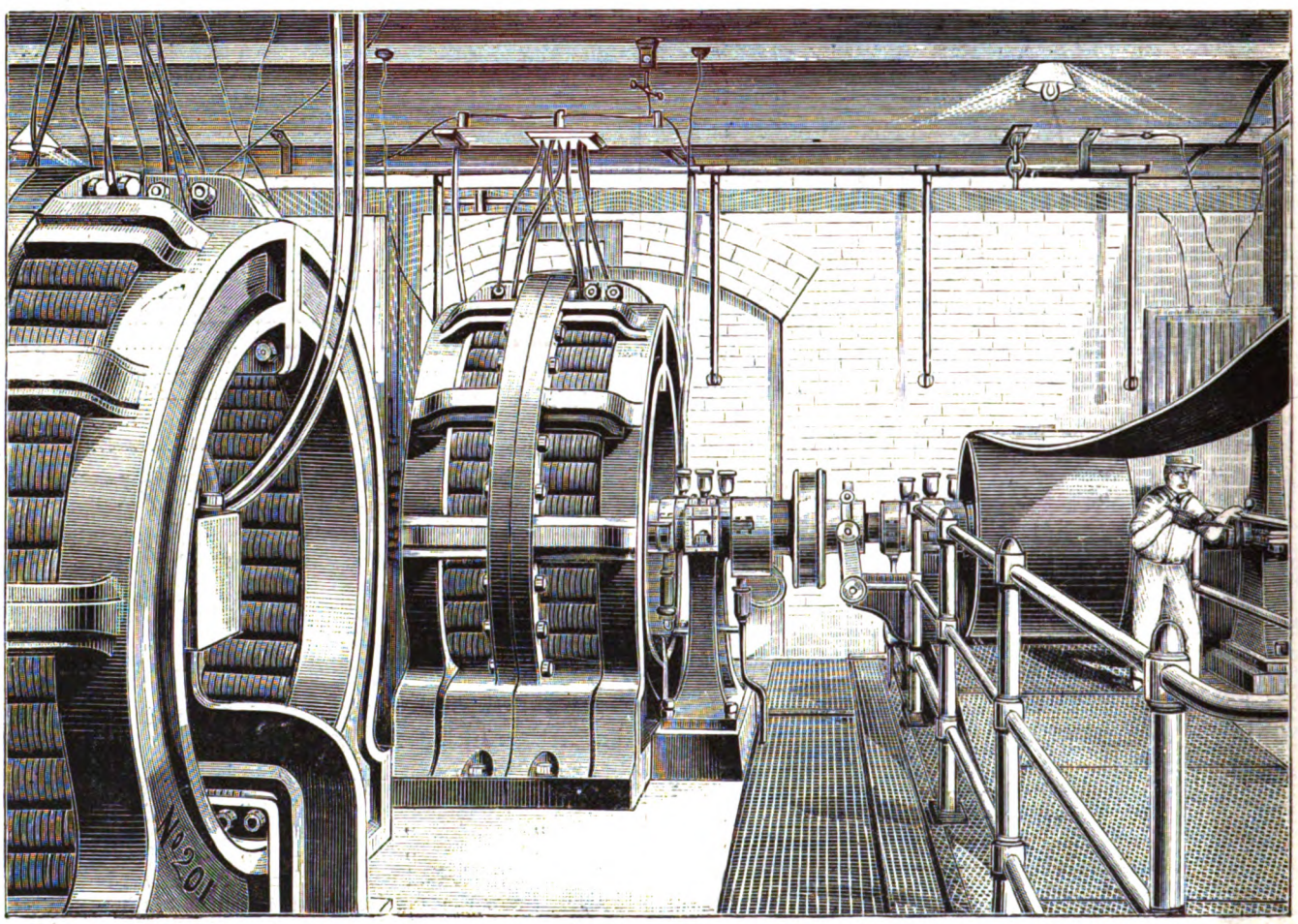
THE GROSVENOR GALLERY CENTRAL LIGHTING STATION OF THE LONDON ELECTRIC SUPPLY CORPORATION.

On Wednesday evening last, at the invitation of the directors of the London Electric Supply Corporation, the representatives of the technical press visited the Grosvenor Gallery, and inspected the Central Lighting Station. Our readers will be already aware that for more reasons than one this station will possess a unique interest in the history of electrical engineering. It was at the Grosvenor Gallery that the transformer system may be said to have had its birth. The installation has been regarded from the first by its promoters as experimental in character, and it is here that the problems have been worked out whose successful solution has imparted that remarkable degree of confidence which is now being displayed in the far vaster undertaking at Deptford. Considered merely as an extended trial of the overhead system of distributing electric lighting currents, the success attained is of the highest importance. It is, however, on account of the experimental character of their operations that the directors have hitherto refrained—and as we have all along been of opinion have wisely refrained—from sanctioning the publication of the details of a technical character. But the time having now arrived when the experimental stage of the Ferranti system is considered to have been closed—save, of course, in so far as the Deptford scheme involves new and important problems on account of its extreme magnitude—we take the earliest opportunity of furnishing our readers with an account of the Grosvenor Gallery installation. We shall confine ourselves at present to a straightforward description of the main features, reserving some of the details for more complete illustration at a later date.



THE 10,000-LIGHT FERRANTI DYNAMO AT THE GROSVENOR GALLERY.

The total number of lamps at present wired in connection with the Grosvenor Gallery Station is equivalent to about 35,000 of 10 candle-power; but it has hitherto been found that 20,000 represents the maximum number in use at one time, and this number is but rarely exceeded. To supply current for these lights, two Ferranti machines are provided, each of which was designed for 10,000 10 candle-power lamps, but one machine alone has proved itself capable of taking a load of no less than 19,500 lamps without injury. These machines stand 9ft. 6in. in height, with a floor space 9ft. by 11ft. The armature is not built up in the way usually associated with the name of Ferranti, but is composed of separate bobbins, after the Siemens type. The coils are wound on laminated cores of gunmetal and German silver, and are composed of copper tape ½in. in width by ·06in. in thickness. The tape is slightly corrugated in order to prevent its slipping on the crown of the core, which is also corrugated to receive it. The insulation is wound on with the tape, and consists of hard vulcanised fibre of ½mm. thickness. One end of the bobbin is soldered to the core, which is insulated from the frame by blocks of ebonite held in cast-iron clamps. In the Deptford machines we understand that an improved method will be adopted. There are forty coils, each consisting of 25 turns, connected 20 in series and two in parallel, so as to keep the points of maximum difference of potential at the opposite extremities of a diameter. The diameter of the armature is 8ft. 6in., and its resistance when hot 1·1 ohm, which at 2,400 volts gives a loss of only 7,000 watts, or 1·36 per cent. on the maximum output. The speed is 260 revolutions per minute, which is equal to a peripheral velocity of 6,942ft. per minute. The field-magnets are eighty in number, and are set very close together, forty on either side. The coils are connected in eight parallels, and have a resulting resistance of one ohm nearly. The field-magnets weigh 17 tons, the base plate

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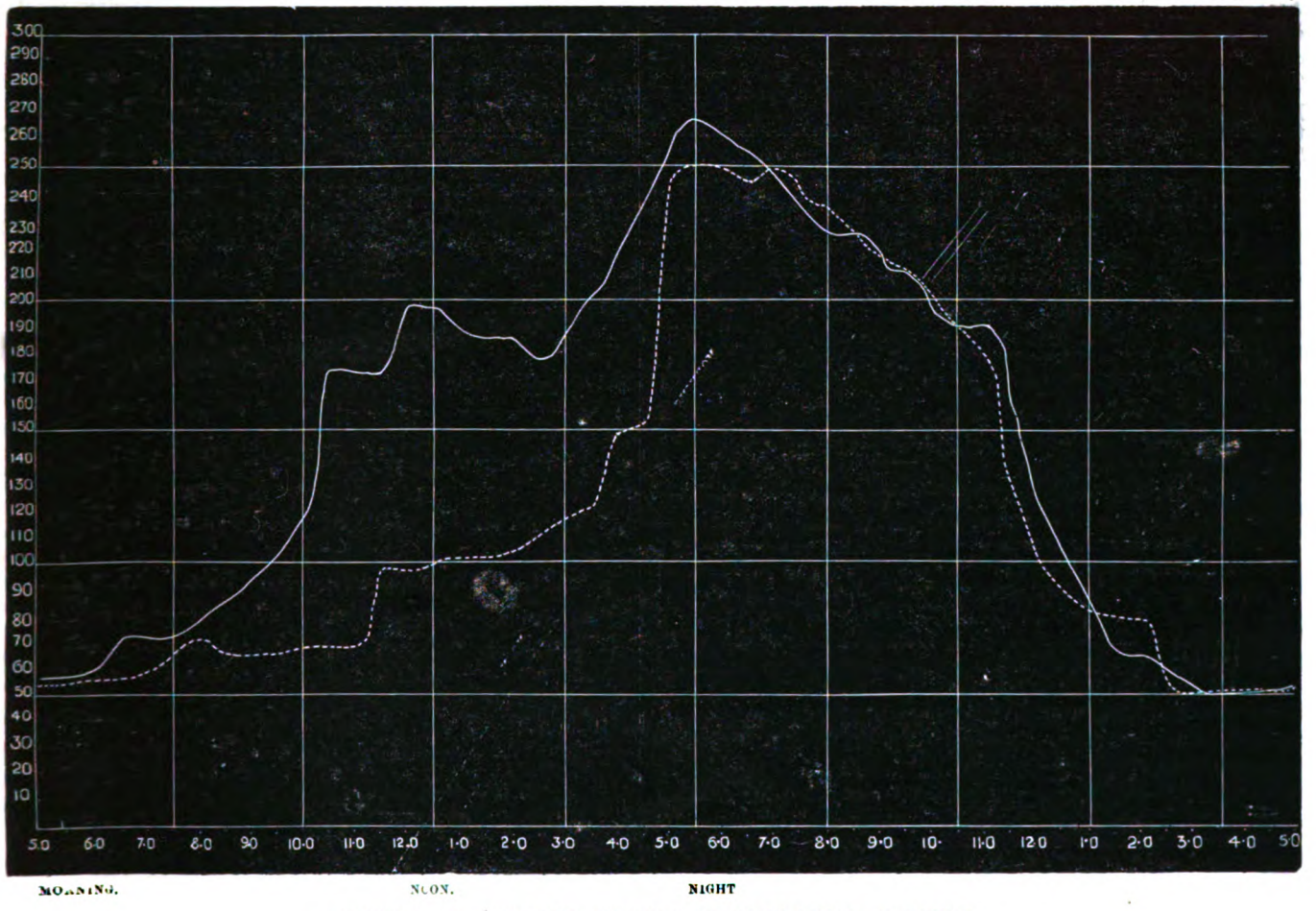
13 tons, the pulley (diameter 5ft.) weighs 2 tons, and the armature one and a-half ton.

The exciters are shunt-wound Siemens machines, giving 100 volts and 108 amperes; they are coupled direct to the shafts of the Ferrantis. The latest addition to the plant is a twelve-unit Kapp machine, also shunt wound, which is at present used chiefly for lighting the engine room, but is also intended as a stand-by for the exciting current in case of need. Switches are arranged for this purpose. There is a constant oil service for each of these machines; the tank holds 300 gallons, and the circulation is effected by two Worthington pumps. Castor oil is used, and the used oil is returned through two strainers.

The engines are four in number, two being Marshall single-cylinder, horizontal engines, of 35 horse-power nominal; one a coupled engine, similar to the above, capable of developing 500 horse-power actual; and one a Corliss, by Hick, Hargreaves and Co., of 750 horse-power. The Marshall engines run at 80 revolutions, and drive on to a single countershaft with clutches so arranged that very nearly any desired combination of engines and dynamos may be effected. The smaller engines have 19in. cylinders with 3ft. stroke, and fly-wheel 13ft. in diameter. The coupled engine has 17in. cylinders, with 3ft. stroke and fly-wheel 12ft. in diameter. The Corliss engine has 33in. cylinders, with a 4ft. stroke, and a fly-wheel 18ft. in diameter. One of the large machines is driven direct from the fly-wheel of the Corliss engine by rope gearing. The other machine is connected by means of a claw clutch with the countershaft driven by the Marshall engines, as already described. The clutch has been specially designed for this purpose by Mr. Ferranti, and it is so effective that when the machine is loaded to 400 horse-power a change can be made without any perceptible effect upon the lamps.

The regulation of the dynamos is effected solely by the governing of the engines. Ordinary centrifugal governors of Hartnell's type are used, and the speed is regulated in accordance with the indications of a Cardew voltmeter by means of a weight sliding on a lever arm. Nothing is more striking in the whole installation than the simplicity and effectiveness of the governing arrangement. The Cardew voltmeter is used only as a "voltascope"—that is to say, it is connected with a small transformer, and its indications are on an arbitrary scale.

The steam generating plant consists of a battery of four Babcock and Wilcox boilers, each of 150 horse-power, worked at a pressure of 130lb., and blowing off at 135lb. When the station is in full swing all four boilers are required, so that there is practically no reserve. The fires are only drawn on Sunday. The water-tank contains a three-days' supply, and there is storage capacity for thirty-six tons of coal. The average daily consumption amounts to 23 tons. The boilers are placed in an excavation, this room being connected with the engine room by a tunnel 40ft. or 50ft. in length, which also serves as a ventilating shaft. The offices and stores are above the boilers, with the water tank on the top story. The ventilation is effected by means of a 72in. Blackman air propeller, running at 200 revolutions, which is found to do its work with remarkable efficiency.



CURVES OF CURRENT OUTPUT AT GROSVENOR GALLERY.

The dotted curve was taken on Monday, October 29th, and the upper curve on Thursday, 1st inst., when a dense fog occurred.

Coming now to the circuit arrangements and the distributing plant—the current passes direct from the machines to a pair of Sir William Thomson's ampere-balances, capable of measuring 250 amperes. The maximum current taken off each machine is about 210 amperes. The machines are run independently—that is to say, they are not electrically coupled in parallel. The external circuits are five in number, and the main switches are specially designed by Mr. Ferranti for breaking on the high-tension of 2,400 volts. The break is no less than 4ft. in width, and is made with great rapidity. Next week we shall give illustrations of this switch, in which Mr. Ferranti's accustomed ingenuity is markedly displayed. The main fuses are each

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about two feet in length, and consist of tin wire, several fine wires being joined in parallel. They are mounted on plugs provided with long ebonite handles, by which they can be readily replaced. It is, however, a very rare event for a fuse to go off.

The main wires on the overhead circuit are all of 19/15 strand cable, insulated with rubber and braid, suspended by leather thongs from 17/16 steel cables. The thongs are about 7in. in length and ¾ wide. The steel wire is shackled off at each pole, and Johnson and Phillips's well-known oil-cup insulators are now exclusively employed. The insulation resistance of the line amounts as a rule to about 3,500 megohms per mile. On the roof of the gallery is a main derrick, of iron lattice work, erected by Messrs. Saxby and Farmer, designed for 12 separate circuits. On ordinary house-tops iron poles of 3⅜in. diameter are employed, and are let into cast-iron sockets in the usual manner; about 400 of these poles have been erected, and over 100 miles of wire have been run, whilst up to the present time not a single breakage has occurred. It need hardly be said that this is a result which reflects the highest possible credit on the engineering staff. All streets are invariably crossed at right angles. The return wire is carried over the same line at a vertical distance of 1ft. below the positive lead, and not the least disturbance is now complained of on adjacent telephone circuits. Branch wires are usually 7/16 strand, and house wires 7/20. The external house wires are enclosed in earthenware piping, which is usually let into the wall. Before joining the transformer they pass through a safety fuse and a main switch. The junction of the primary wires with the transformer is made at the bottom of a deep groove in the outer casing of the transformer, and can only be got at by a screwdriver of extra length.

The Ferranti transformer was described and illustrated in *The Electrician* of February 10th, 1888, page 346. On the consumer's premises they are enclosed in a fire-proof casing, and are fixed in cellars or outhouses, or wherever a convenient place can be found. With the exception of a slight mishap at Lord Brassey's residence, of which unduly magnified accounts were circulated, no trouble whatever has been occasioned by the transformers. The main switches in the consumer's premises are all of the double pole type, the break being made instantaneously on each side. It is, perhaps, not generally known that the spark on breaking an alternating current is decidedly smaller than that which is given by a continuous current under the same conditions. It is also a singular fact that under certain conditions and within certain limits the spark is more vivid with a small current than with a larger one. On these circuits it is a fact that with a 20-ampere current the spark is less intense than with one-quarter of an ampere. The insulation between the primary and secondary of the Ferranti transformer is remarkably high. The core is first wound round with several layers of linen soaked in shellac, each layer being allowed to dry slowly. An outer coating of shellac paper is put on, and over this the secondary coil is slipped. The primary coil is usually made in twelve sections connected in series, so as to distribute the potential as much as possible; the sections are separated by shellac paper. The primary is insulated from the secondary in the same way as the secondary is insulated from the core. The transformers are made in the following standard sizes:—2½ horse-power, 5 horse-power, 10 horse-power, 15 horse-power, and 20 horse-power. These figures are, however, merely nominal; Mr. Ferranti seems always to allow himself an ample margin, and we are assured that the 2½ horse-power size has easily carried a load of 61 16 candle-power lamps, which is about equal to 6 horse-power. As a rule, the transformers are designed for 100 volts at the secondary terminals. From these terminals the house wires are taken to the meter, and from the other side of the meter the wires are the property of the customer, and the responsibility of the company ceases.

By far the greatest number of the lamps supplied are 10 candle-power incandescents; there are, however, a few Sunbeams, and about 14 or 15 arc lamps. Most of the latter are employed by photographers in Regent-street, and are regulated by hand. The lamps outside the Haymarket Theatre are of the Brockie-Pell type, and are run two in series off a 100-volt transformer.

The adjacent illustration (Fig. 1) is taken from a photograph of the machine room, and shows the two large Ferranti dynamos. The curves of current output in Fig. 2 are of a very interesting character. It may be as well to add that the ordinates representing current may be interpreted in lamps on the basis of about 4,000 lamps for each 50 amperes of the primary current. The effect of last week's fog is very evident in the upper curve.

REVIEWS.

Central Station Electric Lighting: with Notes on the Methods used for the Distribution of Electricity. By KILLINGWORTH HEDGES. (London: E. and F. Spon, 1888.)

From an incidental remark in the preface, and also from the presence of a "glossary of technical terms," we gather that in the intention of the author this book is addressed to the non-technical reader. We are, however, inclined, on the whole, to think that Mr. Hedges would have been better advised if he had allowed his ambition to take a higher, if somewhat less extended, flight—that is to say, if Mr. Hedges could have been prevailed upon to confine himself to a descriptive account of the central stations at present existing in this country, together with some notice of the more important installations in Europe and America, the volume would almost certainly have been one upon which it would have been easier to have passed a favourable judgment. But since we have to deal with the book as it stands, we are bound to confess that the pages which are specially intended to assist the comprehension of the non-technical reader, and particularly the earlier part, are but little calculated to increase the scientific reputation of the author. Such definitions as these:—"Potential: a difference of E.M.F., or high and low tension;" "Current, alternating: the intermittent flow in two directions," are scarcely worthy of the distinguished inventor of the duplex cut-out. We confess also that we read with some impatience a remark such as that on page 9—"The arc light is now well understood to be caused by the extremely high temperature of the end of one or both the carbon electrodes." Similarly vague and pointless statements are sadly frequent upon the pages in which the author is dealing with first principles.

When, however, Mr. Hedges settles down to the description of particular installations we find a considerable improvement in style, and much information has been put together which our readers will find it convenient to possess in a form adapted for ready reference. The tabular statements giving numerical and other data relating to central stations in this country and abroad are of considerable value. It is, however, to be regretted that Mr. Hedges should omit all description of the dynamos and engines, or of the method of regulation—these are not unimportant details in connection with central station lighting. The following stations are described, with more or less detail, in the order given:—Paddington, Grosvenor Gallery, Eastbourne, Tivoli, Lucerne, Milan, Berlin, Temesvar, Kensington Court, and Vienna. We notice that Mr. Hedges is under the impression that the "divided-main" system of regulation, as designed for the Paddington installation, is a device of special utility. We presume, however, that Mr. Gordon himself no longer holds this view.

Kirchhoff's Laws and their Application. By E. C. RIMINGTON. (London: Alabaster, Gatehouse and Co. 1888.)

This is a little *brochure* of some 50 pages, reprinted from the columns of our contemporary, the *Electrical Review*, and is likely, we think, to prove very useful to students. The application of the laws of Kirchhoff, in the form in which the student usually finds them stated in the text-books, to finding the distribution of the current in a network of conductors, generally proves a very cumbersome process when the student is left to his own unaided ingenuity. Clerk Maxwell has, however, shown ("Electricity and Magnetism," Second Edition, Vol. I., page 274) how, by the introduction of the idea of "cyclic currents" for each closed mesh, and the application of determinants to the solution of the resulting equations, the process may be carried out in a systematic and more simple fashion. In a Paper read before the Physical Society in June, 1885, Dr. J. A. Fleming illustrated this method by several interesting examples, and he also extended the theorem to the

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determination of the *resistance* between any given points in the network. In *The Electrician* of October 23rd, and two following issues in the same year, Dr. Fleming's Paper was treated in a somewhat simplified manner, and the elementary principles of determinants were explained. Mr. Rimington has now recast the subject in a form well adapted for the comprehension of those whose mathematical attainments are of the slenderest character, and he has added some theorems of his own which will be useful.

KENSINGTON COURT (DRAFT) LICENSE, 1887.

The following is the draft license which has been issued by the Board of Trade for the regulation of the supply of current from the Kensington Court central lighting station. This draft is, however, subject to reconsideration and amendment:

Regulations and conditions for securing the safety of the public, and for ensuring a proper and sufficient supply of electricity, made by the Board of Trade, under the provisions of the Electric Lighting Act, 1882, and the Kensington Court Electric Lighting License, 1887.

In these regulations, the words, terms and expressions to which, by the Kensington Court Electric Lighting License, 1887, meanings are assigned, shall have the same respective meanings, provided that in these regulations

The expression "the license" shall mean the Kensington Court Electric Lighting License, 1887.

The expression "the undertakers" shall mean the undertakers for the purposes of the license.

The following regulations are made subject to the power of the Board of Trade to make such further or other regulations as they may think expedient for the purposes above mentioned.

I.—REGULATIONS AS TO SAFETY.

1. The electricity shall be delivered to the poles on the consumer's premises in some manner free from risk of causing fire on the premises in question, whether such fire should or might be originated during or in consequence of a proper or improper supply of electricity, or by reason of the cessation of any supply, or should or might be partly due to any defective action of the lamps, motors, storage cells, conducting wires, or other fittings connected with the poles for the purpose of using the supply of electricity.

2. The poles, service lines, and other conductors connected with the service lines between the poles and source of supply, so far as they shall be on the consumers' premises, shall be completely enclosed in insulating cases, or thoroughly coated with insulating material, in such a manner that no part of them can be touched by any person without the removal of such case or coating.

3. Alternating currents shall not be used.

4. Where any portions of any electric lines belonging to the undertakers are exposed in such a position as to be liable to be struck by lightning, they shall be efficiently protected by lightning dischargers, of such a pattern and construction as may be from time to time prescribed or approved by the Board of Trade.

5. The difference of potential between any point of any electric line used for charging storage batteries and the earth shall not exceed 250 volts.

6. The difference of potential at corresponding points of the positive and negative conductors used as service lines to any consumer's premises shall not at any time exceed 115 volts, and no portion of such service line shall be at a potential differing from that of the earth by more than 230 volts.

7. The undertakers shall provide and fix to the satisfaction of the Board of Trade such apparatus as the Board of Trade may from time to time consider advisable, in order to prevent the limits of difference of potential for the time being prescribed by regulations from being exceeded.

II.—REGULATIONS AS TO SUPPLY.

Notice of Intention to Supply through any Distributing Mains to be given to Local Authority.

8. One week, at least, before commencing to supply electricity through any distributing main the undertakers shall serve a notice upon the local authority of their intention to commence such supply, and that the said main is ready to be tested.

Undertakers to provide constant supply.

9. From and after the time when the undertakers commence to supply electricity through any distributing main, they shall maintain in such main a current of electricity sufficient for the use of all the consumers for the time being entitled to be supplied from such main, and such supply shall, except so far as may be otherwise agreed upon, from time to time between the local authority and the undertakers be constantly maintained at such pressure as may be prescribed by the regulations for the time being in force. Provided that for the purposes of testing or for any other purposes which the Board of Trade may consider necessary for the efficient working of the undertaking, the undertakers may with the permission of the Board of Trade discontinue the supply of electricity at such intervals of time and for such periods as the Board of Trade may think expedient.

Pressure on Mains during Supply.

10. During the whole of the period when a supply of electricity is required to be maintained by the undertakers in the distributing mains under the license and these regulations (in these regulations termed "the hours of supply"), the potential at corresponding points of the positive and negative distributing mains shall differ at each point by a constant difference (in these regulations termed "the standard pressure") to be fixed as hereinafter specified. Provided that the undertakers shall be deemed to have complied with the requirements of this regulation so long as the difference in potential does not at any point vary more than 3 per cent. from the corresponding standard pressure unless changes in potential recur so frequently as to cause unsteadiness in the supply.

Limits of Standard Pressure.

11. The standard pressure may be different for different points of any distributing main, but shall not be such as to cause a difference of potential at any consumer's poles of more than one hundred and fifteen volts.

Fixing of Standard Pressure.

12. The "standard pressure" shall be fixed by the undertakers for every distributing main, and notice of the amount of such standard pressure shall be given to the local authority before the undertakers commence to supply electricity to consumers through such main, and shall not be altered except by permission of the local authority, and upon such terms and conditions as the local authority may impose, and after public notice has been given during a period of one month in such manner as the local authority may require of the intention of the undertakers to apply for permission to alter the same, provided that the undertakers may appeal against any decision of the local authority under this regulation to the Board of Trade, whose decision shall be final.

Supply to be given at one or more pairs of poles on consumers' premises.

13. The supply of electricity upon any premises shall (except by agreement) be given at one or more pairs of poles situated thereon, the respective poles of each pair being situated at a safe and convenient distance from one another, and being in connection respectively with the positive and negative mains, and the undertakers shall be responsible for the maintenance of such poles and any other lines, fittings, and apparatus belonging to the undertakers, or under their control, upon such premises in a fit and proper condition for supplying electricity; but the undertakers shall not be in any way responsible for any defects in the construction of any electric lines or fittings within such premises, whether for the utilisation of the electricity supplied or otherwise, where such electric lines or fittings have not been supplied by them, nor for any neglect in the maintenance of any such electric lines or fittings where they do not belong to the undertakers, or are not under their control.

Pressure at Poles on Consumer's Premises.

14. The resistance of the service lines by which the supply is given to any consumer shall not, except by agreement, be greater than would cause the difference of potential at the positive and negative poles on any consumer's premises to be less than the corresponding difference of potential at the point of junction of the distributing mains and service lines by which the said consumer is supplied by more than *one* per centum of the corresponding standard pressure, when the maximum current with which he is entitled to be supplied by the undertakers under the license is passing through such service lines, or such other percentage as may from time to time be approved of by the Board of Trade, either generally or in respect of individual cases.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, November 10th.

PHYSICAL SOCIETY (London).

3 p.m. "On the Coefficient of Mutual Induction of a Helix and a Coaxial Circle." By Prof. J. V. JONES.

TUESDAY, November 13th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read: "Friction Brake Dynamometers." By W. WORBY BEAUMONT, M.I.C.E. At this meeting the medals, premiums and prizes awarded at the close of the last session will be distributed by the President.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture: "India." By Mr. HAROLD COX.

FRIDAY, November 16th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read: "Experiments on Beams." By Mr. ED. C. DE SEGUNDO C.E.

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The Electrician.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
Within Postal Union	6 6	12 6	24 0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

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"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received.

CONTENTS OF THE CURRENT NUMBER.

Notes	1	The Financial Position of the London Electric Supply Corporation	20
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued	6	American Notes	20
Lightning Conductors.—II. By Dr. Oliver Lodge. Illustrated. Continued	7	Notes from Paris	22
The Grosvenor Gallery Central Lighting Station of the London Electric Supply Corporation. Illustrated	10	Notes from Scandinavia	22
Reviews	12	Correspondence	23
Kensington Court (Draft) License, 1887	13	The Society of Telegraph Engineers and Electricians— On Ocean Temperatures in Relation to Submarine Cables. By W. Lant Carpenter, B.A., B.Sc. Illustrated.	25
Meetings of Scientific Societies	13	Notes on Gearing for Electric Railways. By Mr. Almon Robinson	28
"Electricity, our Defence."	14	The Electrical and Allied Trades' Section of the London Chamber of Commerce	30
Ourselves	15	Patent Record	31
Hertz's Researches on Electrical Oscillations. By G. W. de Tunzelmann, B.Sc. Illustrated. Continued	16	Companies' Meetings, &c.— West India and Panama Telegraph Company	32
The Tesla Motor and Westinghouse Station Switch-board Arrangement. Illustrated	18	Australasian Electric Light, Power and Storage Co.	32

VOLUME XXI. OF "THE ELECTRICIAN."

Volume XXI. of "The Electrician" is NOW READY,
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THE INDEX TO VOLUME XXI.

The Index to Volume XXI. is presented Gratis with the current number of "The Electrician."

Complaints of non-receipt should be promptly forwarded to the Publisher.

"ELECTRICITY, OUR DEFENCE."

Speaking at Islington on the 1st inst., Mr. Stanhope enumerated some of the various ways in which our coast defences should be improved; and he dwelt particularly upon the importance for this purpose of electrical submarine mines. Had the Secretary for War possessed the advantage of reading Captain Zalinski's lecture, delivered a few days before in New York on a similar subject, his recommendations would have been possibly more emphatic, and his confidence in electrical defences still more pronounced. Captain Zalinski, of the United States Army, is best known in England in connection with the famous dynamite gun, of which we shall have to say more presently; but his lecture at the Electric Club was devoted to a general survey of the ways in which electricity has been adapted to the appliances of warfare, or, more exactly, of the improvements effected in those appliances by the application to them of electrical science. The title of his Paper was "Electricity as used in Sea Coast Defence," but with their usual felicity the American press have re-named it "Electricity, our Defence," a title which is so truly appropriate here that we have not scrupled to place it at the head of this article.

Captain Zalinski classifies his electrical subject roughly as follows: Military telegraphy; range and position finding; lighting; motors; manipulating guns; directing torpedoes; igniting mines and firing torpedoes and guns. In the last named of these the lecturer probably included the ignition of gun charges, as is done in the case of the pneumatic dynamite

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gun, the projectile of which carries its own batteries and is exploded electrically either by contact with water, or by making electrical contact on concussion against a solid substance. The best form of fuse was of such importance in connection with this invention that some very exhaustive and valuable experiments were carried out in conjunction with General ABBOT, U.S.A., and other gentlemen, resulting in the adoption of a low-tension fuse of platinum-iridium being selected for the bridge, as having a higher resistance and lower specific heat than pure platinum. It is with fuses of this character that the charge of the pneumatic gun is exploded. The problem in this case was to protect the filament from rupture prematurely, but Mr. SMITH, Captain ZALINSKI's assistant, has succeeded in making a bridge solidly embedded in a pellet of compressed powder. Protected in this way it is possible to use the electrical fuse in an ordinary gunpowder shell. For the pneumatic gun two small batteries are enclosed at the rear of the charge, one dry, the other wet, and are ingeniously arranged so as to prevent accident, but to ensure their final action when once projected from the gun. The experiment with the "Silliman," a small vessel, 80 feet long, resulted in its complete destruction at a one mile range, after three or four rounds of dynamite had been discharged. The accuracy of the firing seems to have been remarkable, and in no instance did the shell fail to ignite.

With Captain ZALINSKI's description of the present condition of military telegraphy we need not trouble our readers here, as most of his examples are taken from English or German sources. A similar remark will apply to his interesting account of subterranean and submarine mines, full reports on the latest improvements of which have recently appeared in these pages. The great value of these appliances, however, for coast defence is insisted upon with much force of argument and illustration in Captrin ZALINSKI's lecture, and we commend it to the consideration of the naval and political authorities of this country. Naturally, Major WATKINS' range and position finder occupies a prominent place in the lecture; and a very good attempt is made to lay bare the secret for which the English Government paid £25,000, and is paying a ten years' annuity of £1,000. So long as the States keep on friendly terms with the mother country we shall always be pleased to hear that "American electricians could do quite as well in this field of ingenuity" as the English Major WATKINS. Just at present, however, we are rather glad they have not hurried themselves.

The merits and demerits of the electric light for revealing the position of the enemy are fully gone into by the lecturer, but with no very definite pronouncement. The Mangin projector is the form used in America; and it is urged that hand-regulation is preferable to automatic, in order to obtain any required length of arc, and for other practical considerations, especially on shipboard. With much greater confidence does the author speak of the employment of the electric motor for the working of guns, a method which he rightly argues is far superior to hydraulic or pneumatic machinery in point of safety and efficiency. Captain ZALINSKI cordially approves of a suggestion to work the dynamo for electric lighting of military trenches by horse-power. The dynamo and horse-power apparatus would be comparatively light and easily transported. It is interesting to note that Major G. S. CLARKE, of the Royal Engineers, is credited with this capital idea. Apparently the best American ideas on the subjects here discussed emanate from the corresponding branch of the U.S. army. On the importance of keeping up the technical and scientific training of the Engineering Corps Captain ZALINSKI is very emphatic, and he utters some much needed words of warning on the prevalent misunderstanding as to the simplicity of submarine mining, and the ease with which it is supposed to be capable of being improvised. The problem of harbour and coast defences is, to quote his own words, "complex in character, requires the greatest care in the preparation of material and in the training of the *personnel* to manipulate it. Every detail must be carefully prepared; there must not be a single weak link in the chain, or the system is likely to fail." The author gives us credit for being ahead of the States in these respects; but none the less, at a time when we are extending our system of defences, the conditions on which their usefulness depend should be constantly kept in view. The sufficiency of the appliances themselves, and the part played in them by electricity as shown in Captain ZALINSKI's Paper, would justify us in saying that, properly directed, they can hardly fail to secure for us that immunity from external assault concerning which the recent naval manœuvres left us with some misgivings.

OURSELVES.

It has been our custom not infrequently at the commencement of a new volume of this journal to congratulate its readers on the development and progress of electrical industry as exemplified in the pages of THE ELECTRICIAN during the past year. Established more than ten years ago, when electrical research was beginning to be turned to many practical purposes besides those of telegraphy, to which previously it had been chiefly confined, THE ELECTRICIAN has steadily promoted and been closely identified with these later developments, and may now claim to be the representative organ of the professions, manufactures and trades which are classed under the heading "Electrical." On the present occasion no apology is needed for reverting to the custom above-mentioned, the past year having been an exceptionally encouraging one as touching ourselves, and also, we have reason to believe, for those whose interests it is the privilege of this journal to promote and defend. From time to time, as the area of its influence became widened, THE ELECTRICIAN has been enlarged and its contents improved. A notable instance of this occurred twelve months ago, when, under new editorial and managerial supervision, THE ELECTRICIAN took a step far ahead of anything ventured upon before. Not only was the journal greatly increased in size, but an endeavour was made to raise the tone and to increase the usefulness of its contents. No effort has since been spared to supply our readers with original contributions from the leading scientific and practical electricians of the day, and to carefully record the discoveries and advances which have been made both in America and on the Continent of Europe. That these efforts have been appreciated we have assurances from all quarters of the globe where THE ELECTRICIAN circulates; assurances which find substantial confirmation in its largely extended sale and its increased advertisement columns. If, as we have said and believe, the progress of electrical industry coincides with the prosperity of its leading representative in the press, our clients have as good reason as ourselves to be more than satisfied with the past year's work.

The part which the Electrical Press has played in the directing and aiding the revival and extension of electrical business can hardly be exaggerated. The wider publicity given to the discoveries of science and the applications of invention have immensely hastened their practical adaptation to the needs of society, so that what was once an isolated and localised advantage is nowadays instantly made the property of the whole world. Science and practice are also in this way made to react upon each other; and it is not too much to say that the promptitude with which scientific lessons are taken up and

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turned to account has vastly quickened the activities of pure science to an extent never before experienced. The attention now being devoted to electrical research is quite unprecedented in the annals of science; and its utilisation to mechanical and practical appliances is hardly less remarkable. No better evidence of this can be found than in the increased bulk of the ELECTRICIANS' DIRECTORY for the current year; and this will be still further demonstrated in the forthcoming volume, which is now being prepared. The formation of an Electrical Section in the London Chamber of Commerce, and the change of its title by the Society of Telegraph Engineers, may be mentioned in this connection. The amplification of our own title, by the addition of the words "Journal of Electrical Engineering, Industry and Science," has therefore been fully justified. We may also point to the technical and industrial journals of this and other countries in proof of the high esti mation in which electrical inventions are now held. The fact is encouraging, but it by no means meets the real requirements of the electrical world—requirements which must be satisfied by the fullest scientific as well as the soundest technical information. This can be provided only by organs devoting themselves exclusively to the subject, and of these it has been our ambition—in which we believe we have succeeded—that THE ELECTRICIAN shall be the foremost. As an electrical authority it has long occupied this position among technical journals; and as a trade organ, with a circulation now greatly in excess of any other English electrical paper, its standing cannot be gainsaid. It is in no spirit of idle boasting that we put these simple facts before our readers at the present moment. To them it is a matter of greater importance even than to us. We have always held that their interests were closely bound up with those of THE ELECTRICIAN, and what we are now saying is substantially this, that our friends have frankly admitted the fact by affording that support and patronage without which no journal can continue to exist. Our prosperity, we take it, is a mark of their contentment; and in congratulating ourselves we are congratulating them. Those efforts which we have made in the past will not be relaxed in the future. The series of portraits which have appeared with this journal will be continued from time to time, and we feel great pleasure in announcing that a portrait of SIR WILLIAM THOMSON, the first President of the newly-named Institute of Electrical Engineers, is now in preparation. Allusion has already been made to the publication in these pages of reports from foreign countries relating to electrical affairs. Our regular weekly letter from the United States, where the greatest activity prevails in all branches of electrical industry, has been highly valued; and steps are being taken to obtain similar letters more frequently than at present from responsible correspondents in the chief European centres.

One other change connected with the proprietorship of this journal it may be well to mention here. The reprinting in book form of Papers contributed to THE ELECTRICIAN, the publication of the ELECTRICIANS' DIRECTORY, and the preparing of new books placed with us for publication, had grown into a business of such importance, that a somewhat more definite title was needed to designate the printing and publishing establishment of which THE ELECTRICIAN newspaper is the central figure. The ownership of the paper has in no other respect changed; but its proprietors, for business purposes, have thought it more convenient to assume the position which the law permits in such cases, and they are now known as THE ELECTRICIAN PRINTING AND PUBLISHING COMPANY (LIMITED). Among the works which already have been published or are being prepared for publication by this Company may be mentioned Dr. FLEMING'S work on Alternating Current Transformers, Prof. EWING'S on the Magnetisation of Iron, Prof. PERRY'S Mechanical Construction of Dynamos, Dr. GORE'S Electrolytic Separation of Metals, Mr. WILKINSON'S Practical Notes for Electrical Students, Mr. BEAUMONT'S work on the Steam Engine Indicator, and several others. Lastly, we have made reciprocal arrangements with the leading American electrical journal, *The Electrical World* of New York, under which that periodical and its subsidiary publications are on sale at this office, and those of THE ELECTRICIAN COMPANY at the office of *The Electrical World*.

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.SC.

(*Continued from page 789, Vol. XXI.*)

Interference of the Direct Actions with those Transmitted through the Wire. If the square circuit B is placed at the null point in the second principal position, with the air space at its highest point, it will be unaffected by the waves in the wire, but the direct action when in this position was found to produce sparks 2 millimetres in length. B was then turned about a vertical axis into the first principal position in which there would be no direct action of the primary oscillation, but the waves in the wire gave rise to sparks, and by bringing P near enough to A, a sparking distance of 2 millimetres could be obtained. In the intermediate positions sparks were produced in both these ways, and it would therefore be possible to get a difference of phase, such that one should either increase or diminish the effect of the other. Phenomena of this nature were, indeed, observed. When the plane of B was in such a position that the normal drawn towards A A′ was directed away from that side of the primary conductor on which P was placed, there was more sparking than even in the principal position; but if the normal were directed towards P the sparks disappeared, and only reappeared when the air space was made smaller. When the air space was at the lowest point of B, the other conditions remaining the same, the sparks disappeared when the normal was turned away from P. Further variations of the experiment gave results in accordance with these.

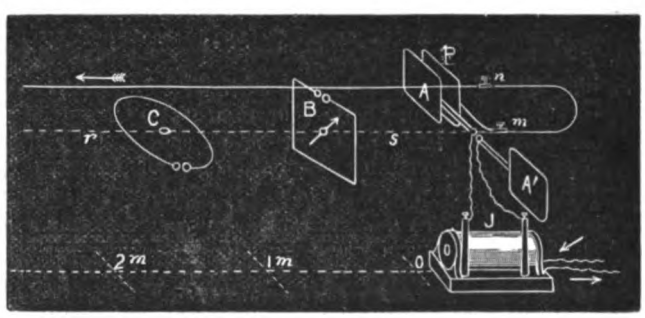

FIG. 11

It is easily seen that these phenomena were exactly what were to be expected. To fix the ideas, suppose the air space to be at the highest point and the normal directed towards P, as in Fig. 11. Consider what happens at the moment that the plate A has its greatest positive charge. The electrostatic, and therefore the total E.M.F., is directed from A towards A′. The oscillation to which this gives rise in B is determined by the direction of the E.M.F. in the lower portion of B. Therefore positive electricity will flow towards A′ in the lower portion, and away from A′ in the upper portion.

Consider next the action of the waves. As long as A is positively charged, positive electricity will flow from the plate P. This current is, at the moment considered, at its maximum value at the middle point of the first half wave-length. A quarter of a wave-length further from the origin—that is to say, in the neighbourhood of the null point—it first changes its direction. The E.M.F. of induction will here, therefore, impel positive electricity towards the origin. A current will

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therefore flow round B towards A′ in the upper portion and away from A′ in the lower portion. The electrostatic and electrodynamic E.M.F.s are therefore in opposite phases and oppose each other's action. If the secondary circuit is rotated through 90 deg., through the first principal position, the direct action changes its sign, but not so the action of the waves, so that they now tend to strengthen each other. The same reasoning holds when the air space is at the lowest point of B.

Greater lengths of wire were then included between *m* and *n*, and it was found that the interference became gradually less marked, until with a length of 2·5 metres it disappeared entirely, the sparks being of equal length whether the normal were directed towards or away from P. When the length of wire between *m* and *n* was further increased, the distinction between the different quadrants reappeared, and with a length of 4 metres the disappearance of the sparks was fairly sharp. The disappearance, however, then took place (with the air space at the highest point) when the normal was directed away from P, the opposite direction to that in which the disappearance previously took place. With a still further increase in the length of the wire the interference reappeared and returned to its original direction with a length of 6 metres. These phenomena are clearly to be explained by the retardation of the waves in the wire, and show that here again the direction of motion in the advancing waves changes its sign at intervals of about 2·8 metres.

To obtain interference phenomena with the secondary circuit C in the third principal position the rectilinear wire must be removed from its original position, and placed in the horizontal plane through C either on the side of the plate A or of the plate A′. Practically it is sufficient to stretch the wire loosely and to fix it by means of an insulated clamp on each side of C alternately. It was found that when the wire was on the same side as the plate P the waves in it diminished the previous sparking, and when on the opposite side the sparking was increased, both results being unaffected by the position of the air space in the secondary circuit. Now it has been already pointed out that at the moment when the plate A has its maximum positive charge and at which, therefore, the primary current begins to flow from A, the current at the first node of the rectilinear wire begins to flow away from the origin. The two currents therefore flow round C in the same direction when C lies between the rectilinear wire and A, and in opposite directions when the wire and A are on the same side of C. The fact that the position of the air space is indifferent confirms the conclusion formerly arrived at, that the direction of oscillation is that due to the electro-dynamic E.M.F. These interferences are also changed in direction when the wire *m n*, 1 metre in length, is replaced by a wire 4 metres in length.

Dr. Hertz also succeeded in obtaining interference phenomena when the centre of the secondary circuit was not in the base-line, but these results were of no special importance, except that they confirmed the previous conclusions.

Interference Phenomena at Various Distances.—Interference may be produced with the secondary at greater distances than that of the null point, but care must then be taken that the action of the waves in the wire is of about the same magnitude as the direct action of the primary circuit through the air. This can be effected by increasing the distance between P and A.

Now, if the velocity of propagation of the electrodynamic disturbances through the air is infinite, the interference will change its sign at every half-wave length in the wire—that is to say, at intervals of about 2·8 metres. If the velocities of propagation through the air and through the wire are equal, the interference will be in the same direction at all distances. Finally, if the velocity of propagation through the air is finite, but different from the velocity in the wire, the interference will change in sign at intervals greater than 2·8 metres.

The interferences first investigated were those which occurred when the secondary circuit was rotated from the first into the second principal position, the air space being at the highest point. The distance of the secondary from the null point was increased by half-metre stages from 0 up to 8 metres, and at each of these positions an observation was made of the effects of directing the normal towards and away from P respectively. The points at which no difference in the sparking was observed in the two positions of the normal are marked 0 in the table below. Those in which the sparking was least, showing the existence of interference, when the normal was directed towards P are marked +, and those in which the sparking was least when the normal was directed away from P are marked −. The experiments were repeated with different lengths of wire *m n*, varying by steps of half a metre from 1 metre up to 6 metres. The first horizontal line in the table gives the distances in metres of the centre of the secondary circuit from the null point, while the first vertical line gives the lengths of the wire *m n*, also in metres.

TABLE I.

	0		1		2		3		4		5		6		7		8
100	+	+	0	−	−	−	−	−	0	0	0	0	0	+	+	+	+
150	+	0	−	−	−	−	0	0	0	0	0	+	+	+	+	+	0
200	0	−	−	−	−	−	0	+	+	+	+	+	0	0	0	0	0
250	0	−	−	−	−	0	0	+	+	+	+	0	0	0	0	0	0
300	−	−	−	−	0	+	+	+	+	+	0	0	0	0	−	−	−
350	−	−	0	+	+	+	+	+	+	0	0	0	−	−	−	−	−
400	−	−	0	+	+	+	+	0	0	0	0	−	−	−	−	−	−
450	−	0	+	+	+	+	+	0	0	0	−	−	−	−	−	−	0
500	−	0	+	+	+	+	0	−	−	−	−	−	0	0	0	0	+
550	0	+	+	+	+	0	0	−	−	−	−	−	0	0	0	0	+
600	+	+	+	+	0	0	−	−	−	−	−	0	0	+	+	+	+

An inspection of this table shows, in the first place, that the changes of sign take place at longer intervals than 2·8 metres; and, in the second place, that the change of phase is more rapid in the neighbourhood of the origin than at a distance from it. As a variation in the velocity of propagation is very unlikely, this is probably due to the fact indicated by theory that the electrostatic E.M.F., which is more powerful than the electrodynamic E.M.F. in the neighbourhood of the primary oscillation, has a greater velocity of propagation than the latter.

In order to obtain a definite proof of the existence of similar phenomena at greater distances Dr. Hertz continued the observations, in the case of three of the lengths *m n*, up to a distance of 12 metres, and the result is given in the table below:—

TABLE II.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	+	0	−	−	0	0	0	+	+	+	+	+	0
250	0	−	−	0	+	+	0	0	0	0	−	−	−
400	−	0	+	+	0	0	−	−	−	−	0	0	0

If we make the assumption that at the greater distance it is only the E.M.F. of induction which produces any effect, the experiments would show that the interference of the waves excited by the E.M.F. of induction with the original waves in the wire changes its sign only at intervals of about seven metres.

In order to investigate the E.M.F. of induction close to the primary oscillation, where the results are of special importance, Dr. Hertz made use of the interferences which were obtained when the secondary circuit was in the third principal position, and the air space was rotated through 90deg. from the base line. The direction of the interference at the null point, which has already been considered, was taken as negative, the interference being considered positive when it was produced by the passage of waves on the side of C remote from P, which makes the signs correspond with those of the previous experiments. It must be borne in mind that the direction of the resultant E.M.F. at the null point is opposed to that of the E.M.F. of induction, and therefore the first table would have begun with a negative sign if the electrostatic E.M.F. could have been eliminated. The present experiments showed that up to a distance of three metres interference continued to occur, and always of the same sign as at the null point. It was unfortunately impossible to extend these observations to a greater distance than four metres, on account of the feebleness of the sparks, but the results obtained were sufficient to give distinct evidence of a finite velocity of propagation of the E.M.F. of induction. These observations, like the former ones,

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were repeated with various lengths of the wire $m\,n$ in order to exhibit the variation in phase, and the results obtained are given in the table below :—

TABLE III.

	0	1	2	3	4
100	−	−	−	−	0
150	−	−	0	0	0
200	0	0	0	+	+
250	0	+	+	+	+
300	+	+	+	+	+
350	+	+	+	+	0
400	+	+	+	+	0
450	+	+	+	0	0
500	+	+	0	0	0
550	+	0	0	0	−
600	0	−	−	−	−

which shows that as the distance increases the phase of the interference changes in such a manner that a reversal of sign takes place at intervals of from seven to eight metres. This result is further confirmed by comparing the results of Table III. with the results for greater distances given in Table II., for in the former series the effect of the electrostatic E.M.F. is eliminated owing to the special position of the secondary circuit, while in the former it becomes insensible at the greater distances owing to its rapid decrease with increasing distance. We should therefore expect the results given in the first table for distances beyond four metres to follow without a break the results given in Table III. for distances up to four metres. This was found to be the case, as is evident from inspection of Tables II. and III.

To show this more clearly the signs of the interference of the waves, due to the electro-dynamic E.M.F., with the waves in the wire, are collected together in Table IV., the first four columns of which are taken from Table III., and the remaining columns from Table II.

TABLE IV.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	−	−	−	−	0	0	0	+	+	+	+	+	0
250	0	+	+	+	+	+	0	0	0	0	−	−	−
400	+	+	+	+	0	0	−	−	−	−	0	0	0

From the results given in this table the author draws the following conclusions :—

(1) The interference does not change its sign at intervals of 2·8 metres. The electro-dynamic actions are therefore not propagated with an infinite velocity.

(2) The interference is not in the same phase at all points. Therefore the electro-dynamic actions are not propagated through air with the same velocity as electric waves in wires.

(3) A gradual retardation of the waves in the wire has the effect of displacing a given phase of the interference towards the origin of the waves. The velocity of propagation through the air is therefore greater than through a wire.

(4) The sign of the interference is reversed at intervals of 7·5 metres, and therefore in traversing this distance an electro-dynamic wave gains one length of the waves in the wire.

Thus, while the former travels 7·5 metres, the latter travels $7{\cdot}5 - 2{\cdot}8 = 4{\cdot}7$ metres, and therefore the ratio of the velocities is 75 : 47, which gives for the half-wave length of the electro-dynamic action $2{\cdot}8 \times 75/47 = 4{\cdot}5$ metres. Since this distance is traversed in 1·4 hundred-millionths of a second, the absolute velocity of propagation through the air must be 320,000 kilometres per second. This result can only be considered reliable as far as its order is concerned; but its true value can hardly exceed half as much again, or be less than two-thirds of this amount. In order to obtain a more accurate determination of the true value it will be necessary to determine the velocity of electric waves in wires with greater exactness.

It does not necessarily follow from the fact that in the immediate neighbourhood of the primary oscillation the interference changes its sign after an interval of 2·8 metres that the velocity of propagation of the electrostatic action is infinite, forsuch a conclusion would rest upon a single change of sign, which might, moreover, be explained, independently of any change of phase, by a change in the sign of the amplitude of the resultant force at a certain distance from the primary oscillation. Quite independently, however, of any knowledge of the velocity of propagation of electrostatic actions, there exist definite proofs that the rates of propagation of electrostatic and electro-dynamic E.M.F.s are unequal.

In the first place the total force does not vanish at any point on the base line. Now, near the primary the electrostatic E.M.F. is the greater, while the electro-dynamic E.M.F. is the greater at greater distances. There must, therefore, be some point at which they are equal, and since they do not balance they must take different times to reach this point.

In the second place, the existence of points at which the direction of the resultant E.M.F. becomes indeterminate does not seem capable of explanation, except on the supposition that the electrostatic and electro-dynamic components perpendicular to each other are in appreciably different phases, and, therefore, do not compound into a rectilinear oscillation in a fixed direction. The fact that the two components of the resultant are propagated with different velocities is of considerable importance, in that it gives an independent proof that one of them at any rate must have a finite velocity of propagation.

(To be continued.)

THE TESLA MOTOR AND WESTINGHOUSE STATION SWITCH-BOARD ARRANGEMENT.

As announced some time ago, work has been actively prosecuted, says the *Electrical World*, by the Westinghouse Electric Company in the construction of an alternating-current motor by which the value of the alternating system as a method of power distribution is largely increased. This new motor, which is illustrated in the accompanying illustration (Fig. 1), is based on the method of electro-dynamic rotation devised by Mr. Nikola Tesla,* and is so constructed that no commutator or contact brush of any kind is required, the armature being without any external electrical connection, and the rotative effort being exerted entirely from the changing polarity of the field-magnets.

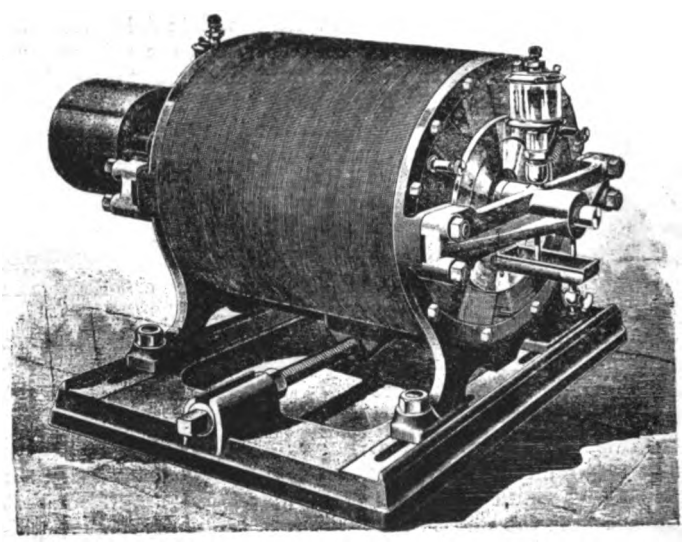

FIG. 1.

The New Westinghouse Alternating-Current Motor.

As will be seen, the motor consists of a series of field-magnets built up of laminated sheet iron and wound with two sets of coils, the ends of which are connected to the two binding posts shown. These binding posts form the only connection with the regular lighting circuits, with the addition of a single return wire. By the aid of this return wire two alternating currents are sent through the field of the motor at the same time, the pulsations of the two currents being equal in strength, but the one lagging a quarter phase behind the other in the two sets of field coils respectively.

* See *The Electrician*, June 15, 1888.

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The effect of this is that a rapidly rotating polarity is given to the field, corresponding in period to that of the currents producing it.

The armature core of the motor is of the Siemens drum type, and it is wound with a comparatively few turns of heavy wire, the ends of which are soldered together, forming a closed circuit having no connection with the energising current. The alternating currents in the field induce secondary currents in the armature, and by the attraction between these and the revolving polarity of the field armature rotation is produced, the rate of rotation corresponding very nearly with that of the field. When no work is being done by the motor, the synchronism is exact, or nearly so, and very little current passes either through the armature or field, but as load is put on and the work increases, the armature tends to lag slightly, causing the passage of more current in proportion to the work done. The reaction between the armature and field is therefore similar to that between the primary and secondary of a converter when changes of lamp loads take place in the secondary circuit. The addition of the return wire for the motor circuit can be made easily, so as to adapt existing lighting circuits to motor work.

The speed of the motor, as well as its direction of rotation, may be regulated by an ingenious adaptation of the converter principle, an adjustable "choking coil" arrangement being employed, which avoids the use of resistances and switches. The simplicity of the winding and general construction of the motor makes it unlikely to get out of repair. Thus the insulation of the armature is of no importance, since the current induced in it, though comparatively large in volume, has a potential of but a few volts, and often less than a volt, regardless of the voltage of the supplying circuits.

The standard station switch-board arrangement adopted by the Westinghouse Company is shown in our illustration (Fig. 2), which represents a board arranged for two dynamos and four lines, any greater number of lines or dynamos simply involving an extension.

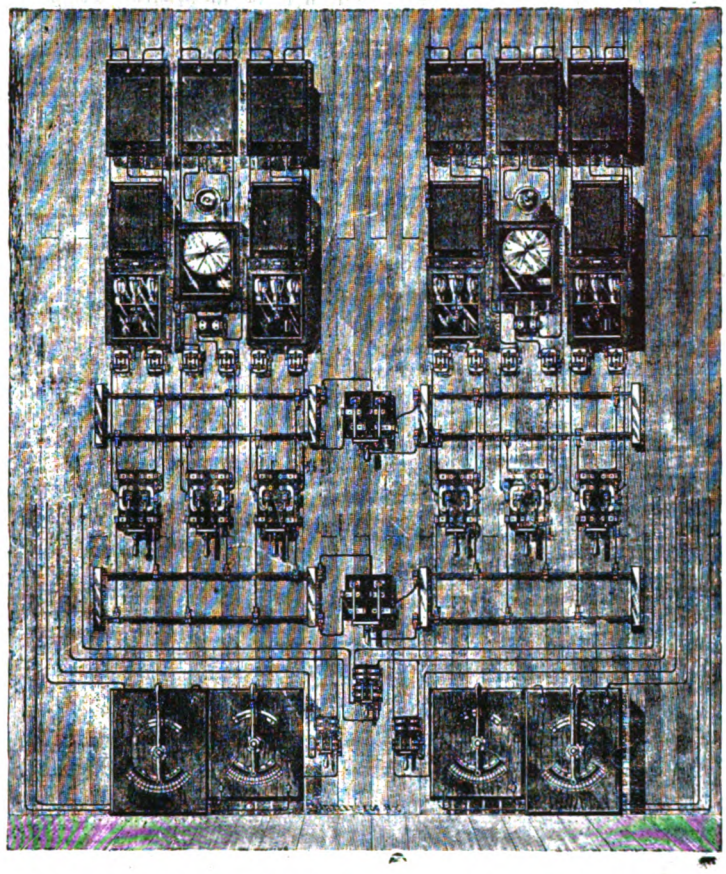

Fig. 2.—Standard Switch-Board for the Westinghouse Alternating-Current Stations.

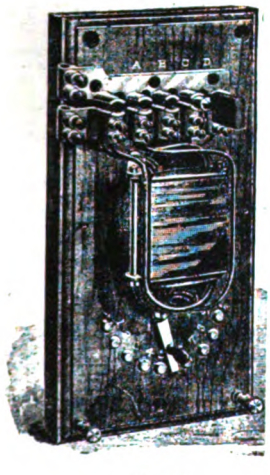

Fig. 3.
Westinghouse Line Pressure Compensator.

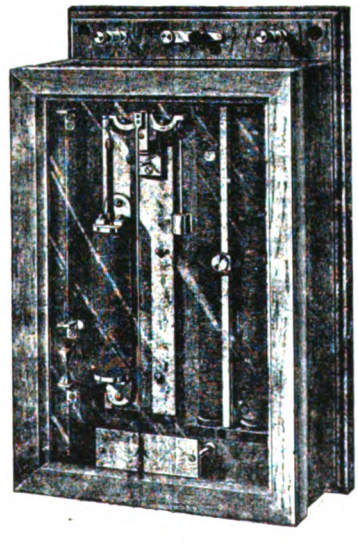

Fig. 4.
Westinghouse Standard Voltmeter.

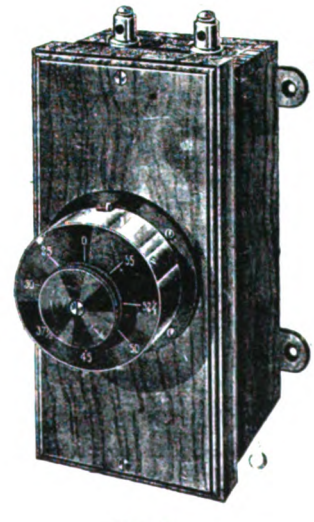

Fig. 5.
Westinghouse House Regulator.

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Commencing at the bottom of the switch-board there are four rheostats, the two small ones nearest the centre being in the field circuits of the exciters. The general practice, as is well known, is to provide each dynamo in such a station with an exciter of sufficient capacity to furnish current to both dynamos. Only one exciter is therefore in service at any one time. It follows, therefore, that the governing of the whole station is performed by the movement of the handle of one only of the two smaller rheostats, the other one being for the time out of service. The two larger rheostats are respectively in the field circuits of the two dynamos, and are used only when it is necessary to equalise their voltage for varying loads, which with well-designed lines is seldom required. The regulation of the station in practice is therefore reduced to a slight movement of the handle of one of the smaller rheostats five or six times in the course of a night's run, with one or two adjustments of the larger rheostats to equalise pressure.

Two small changing switches between the rheostats are used for connecting either exciter with either dynamo at will, and the single small switch immediately over them is used for coupling the field circuits of both dynamos together. When the switches are closed, as shown, both exciters are running connected. This arrangement of the switches, therefore, gives complete control of the supply of exciting current, and prepares for any ordinary emergency.

Over the rheostats are shown four sets of trunk wires, each consisting of two heavy parallel copper rods. Between each upper and lower set are three changing switches. The wires leading to the middle connection of the centre switch come from the dynamo, whose current is, of course, transferred to either pair of trunk wires, according to the position of the switch lever. The two outside switches of each triplet control the two lines respectively, and transfer their connection to either pair of trunk wires as desired.

Between the horizontal sets of trunk wires there are placed two multiple arcing switches, by which the two dynamos may be connected to run together or may be separated at will. By this arrangement either dynamo can serve either line or combination of lines at will, and may be changed by a single movement without interrupting the continuity of the circuit.

Directly over the trunk wires shown there is placed a row of six safety-catch holders, each with double fuses and plug cut-outs. The object of these safety catches is to protect the apparatus behind them from short circuits on the line, and the double fuses provide a ready means for displacement without interruption.

Over the safety catches are placed four voltmeters each with its attendant compensator above it. Each voltmeter registers the voltage on its particular line, and the sole duty of the tender is to see that the needle on the voltmeter does not vary beyond the length of the dotted scale. The compensator, which is shown enlarged in Fig. 3, is in series with the voltmeter, and adjusted at the plug connections to the maximum number of lamps served from it and at a point-switch enclosed within its case to a tabular number depending on the drop in the line. In this manner the indications of the voltmeter are maintained correct for all loads, independent of the varying drop in the line.

Between each pair of voltmeters there is placed an ammeter which indicates the output of the current from the dynamo to which it is connected, and below each ammeter is a short-circuiting plug, which, when plugged in, admits of the ammeter being removed. Over each ammeter is a lamp for the general illumination of the switch-board, and at the top is a row of six small converters, through which the current is reduced for the voltmeter.

Besides the apparatus just described there are several adjuncts to a central station, such as lightning arresters and ground protectors, and a standard voltmeter by which those in daily use are maintained correct.

Our illustration (Fig. 3) shows the enlarged view of the "compensator" above referred to, and Fig. 4 illustrates the standard voltmeter. As it is frequently desirable to reduce the illuminating power of lamps on one circuit without interfering with others, such as in the sleeping apartments at night, the house-regulator shown in Fig. 5 has been designed. This is placed in circuit with each floor-branch of a house, and by setting the pointer, any desired amount of illumination can be obtained without interfering with the remaining lamps in a house.

Electricity in Agriculture.—Prof. Wollny, of Munich, has lately been conducting some experiments upon the action of an electric current on vegetation. The soil experimented on was divided into plots 4 metres square, plates of zinc 30 centimetres broad and 2 metres long being placed at opposite ends of each square. The line was carefully insulated, and five Meidinger cells were inserted in the circuit. The tests were kept up from seed time to harvest, but neither corn, potatoes, nor any other vegetable or cereal, were affected in the slightest degree.

THE FINANCIAL POSITION OF THE LONDON ELECTRIC SUPPLY CORPORATION.

The following is an extract from an article which appeared in *Money* of November 7th:—

We have made it our business to inquire into the position of the London Electric Supply Corporation Limited, of which a good deal has recently been written; and we have come to the conclusion that if ever the electric light is to be a commercial success, it should be so in the hands of this concern. This is not the place to give the history of this corporation, which is the outcome of Sir Coutts Lindsay's experiment of four years back in lighting the Grosvenor Gallery by electricity; but it may be remarked that the demands made upon the Grosvenor station, which was then installed, have increased so steadily that the present corporation has been formed, with an authorised capital of £1,000,000, to erect and equip the new central station at Deptford, from which the directors expect eventually to be in a position to supply the necessary current for 2,000,000 lamps, while they have already invited orders for the supply of electric current for execution early next year.

This is a large order, and some particulars of the corporation and its position will be found interesting. Of the nominal capital of £1,000,000, in £5 shares, rather more than half is at present subscribed, the precise figures being £535,000. The company is by no means a public company in the full sense of the word, for nearly the whole of its subscribed capital is held by eight-and-twenty principal shareholders, as will be seen from the list appended:—

Shareholders.	No. of £5 shares.	Amount invested.
Lord Wantage	45,000	£220,000
Hon. Reginald Brougham	1,148	5,740
Right Hon. Earl Crawford	2,694	13,470
Sir Coutts Lindsay	9,777	48,885
Ince, H.	1,084	5,420
Pyke, Joseph	4,041	20,205
Wade, A.	2,018	10,090
Lord Hillingdon	1,000	5,000
Lord Kennard	1,000	5,000
Henderson, A.	4,167	20,835
Grenfell, H. R.	500	2,500
Currie, B. Glyn and Co.	1,000	5,000
Glyn, Hon. P. C.	1,000	5,000
Kennard, S. E.	1,000	5,000
Benson, R. H.	2,000	10,000
Schiff, A. G.	1,000	5,000
Morrison, Chas.	2,000	10,000
Oppenheim, H.	2,000	10,000
Walker, R. G.	1,500	7,500
Major Waller (retired)	3,800	19,000
Mrs. Lindsay	1,000	5,000
Costello, Manuel	200	1,000
Charrington, A. F.	1,666	8,330
Charrington, H. J.	1,666	8,330
Anderson, A.	300	1,500
Biddulph, G.	200	1,000
Waller, P. R.	200	1,000
Grey, George	300	1,500
Twenty-eight shareholders	92,251	£457,255

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *October 27th*, 1888.

The most important event during this week was the holding of the Seventh Annual Convention of the American Street Railway Association. A year or two ago the meetings of this body were devoted chiefly to the discussion of the care of horses, feed, the protection of hoofs, the different kinds of horseshoes, the disposition of manure, and other similar topics. But now the face of affairs has entirely changed; the veterinary surgeon is rapidly being replaced by the mechanical and electrical engineer, the horse is making way for the cable and the electric motor, and the consequence is that the discussions no longer deal with the horse as a noble animal useful to man, but are largely, if not wholly, concerned with questions relating to the utilisation of mechanical power and the care of machinery. This year the electrical delegation was so large as to excite general comment and attention. While the cable came in for its share in the proceedings, it must be said that electricity was

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unquestionably the lion of the hour. Addresses were made by Mr. W. Bracken, of the Julien Company, on the subject of storage battery work, and by Mr. Barr, of Philadelphia, who had obtained some very satisfactory results there with a Wharton-Reckenzaun car; by Mr. Sprague and Mr. Mansfield, in regard to electrical systems in general, and more particularly the overhead method; and by Mr. R. W. Blackwell on working with conduits. In each department material progress was shown. Mr. Bracken gave an interesting statement with regard to the work done with the Julien cars on the Fourth Avenue-road, and convinced his hearers that the demonstration there not only meant something for the present, but was destined to have a great deal of influence in the future. The greatest interest in this particular installation appears to have been taken by the street railway men, who recognise very forcibly the fact that, after all, the storage car presents the fewest difficulties in the adoption of electricity for street car work in large cities. Mr. Blackwell's presentation on behalf of the conduit was also listened to with close attention, and from what was said by him it was evident that large advances have been made in this field as well as in the others. He made an announcement, too, of great importance, to the effect that the obstructions, legal and other, to work on the conduit road for Fulton-street, New York, had all been overcome, and that work would be begun forthwith to lay conduit for that road, equip the plant, and have the whole installation running before the new year.

Mr. Sprague, as usual, made a lively address, full of good points, on the subject of his road at Richmond and elsewhere, and gave details as to a good deal of new work which he has in hand. He stated that the road which he is now building in the suburbs of Boston for the West End Company, on the overhead system, would have twenty cars and two track-cleaning cars. The station would be equipped with 410 horse-power of steam, and 450 horse-power of dynamos. With that equipment sixty or seventy cars could be run, but only one engine would be started up for the initial equipment of twenty cars. He stated that in Richmond the proportion in the central station of horse-power per car on the road was about 5 or 5½ horse-power, and that at Harrisburg it ran up to about 6 horse-power, which was a good factor for large roads, but on smaller roads 8 to 10 horse-power per car was safer. Mr. Sprague exhibited at Washington the new truck which he has adopted for his street car work. The new motor differs from the old Sprague motor employed for cars in being a single horizontal U-shaped machine, with the cores flattened so as to clear the ground as much as possible, the lowest point being only 9in. below the centre of the axle. Each car carries two of these motors mounted on the usual Sprague method, having two bearings on the car axle, and a flexible spring connection with the car body. Power is transmitted from the armature to the car axle by two sets of gearing, with a total reduction of 12 to 1. No oil cups are used about the motor, all the bearings being self-oiling, and requiring attention but once a day at most. These bearings have also a special dust-guard attachment to keep the oil from working out and the dust from working in. The whole machine and gearing are enclosed in a tight rectangular boxing which is attached to the motor, and moves with it. Each motor will take a steady load of 12½ horse-power, and will work easily up to 15. These new types of motors and cars will be used, I understand, in all the coming Sprague street railway work. The Thomson-Houston Company had the advantage of being able to exhibit in Washington a new electric railroad in full operation. Under the supervision and direction of Captain Griffin, U.S.A., and Mr. G. W. Mansfield, work on the road was rushed through at a tremendous pace, and in spite of the lateness of the date at which consent was obtained from Congress, which, as you probably know, runs the city of Washington as a sort of pocket borough, the road was in readiness for the delegates to see how it worked.

One special feature about the road is that over a long stretch at the beginning the poles are set right down the middle of a broad avenue, so that the brackets carrying the overhead wire stand on each side of the pole. At every third pole there are groups of incandescent lamps, red and white, which when lit up at night practically illuminate the avenue. This piece of work is reported as quite trim and handsome, and as being really an ornament to the thoroughfare. On another portion of the road poles are set on one side, and the overhead wire is carried on brackets; and on a third portion the wire is suspended down the middle of the road between two lines of poles. The road is at present nearly two miles in length, and is rapidly being extended. Three or four cars of the Thomson-Houston type, with twin motors, are in operation, and four or five more are to be added. As may be imagined, all this talk and exemplification of what could be done made no small impression on the Convention, and this was shown in a somewhat amusing way. On the second day one of the delegates, who looked like a very good judge of horseflesh and such excellent things, got up and objected warmly to all this talk about cables and electric motors. He had been running a horse car road for some time, and did not make money out of it, and what he had come to the Convention for was to learn how to do so. He thought the members would be using their time better if, instead of discussing the relative advantages and disadvantages of the storage battery and the overhead system and the conduit, they told him how much hay he ought to give each horse, how to keep their coats in good condition, and how to cool them in the summer and to keep them warm in winter. The appeal was wasted on inattentive ears, however, and instead of showing how well acquainted they were, or once had been, with veterinary practice, the members to a man laughed at their friend and trooped off to lunch. After lunch the advocate of the horse was again on his feet, and made another effort, but with no more success than at first. Little things like these show which way the wind is blowing.

The Westinghouse Electric Company have distinguished themselves this week on the top of their tremendous sensation of last week by publishing undoubtedly the finest catalogue ever issued in this country by an electrical light corporation; in fact, so far as I am aware, it will stand comparison for beauty and completeness with any work of the kind in any line of industry. It is simply superb. It is not merely a collection of handsome engravings, nor simply a catalogue of the price list order, but it is essentially a good technical, well and even gracefully written description of the alternate system. As the electrical papers this week publish some of the cuts, and use more or less of the matter, you will be able to form an idea as to what this catalogue is, if you have not received a copy direct from the company. The work includes the Westinghouse alternating machine and exciter and converter, and the Shallenberger meter, descriptions of all of which have appeared. The new matter included with the old deals with such details as the lightning arrester, the compensator switch-board arrangements, regulators for the house and the stage, and last, though by no means least, the alternating motor of the now well-known Tesla type. It is a multipolar machine, and requires three wires. The motor consists of a series of field-magnets built up with laminated sheet iron wound with two sets of coils. The armature core is of the Siemens drum type, without the commutator, of course; the winding, however, is much simpler, and consists of a few turns of a comparatively small wire, the ends of which instead of being carried out to a collecting ring or any other form of sliding contact are soldered together, forming a closed circuit, having no connection with the energising current. The alternating currents in the field induce secondary currents in the armatures, and by the attraction between these and the revolving polarity of the field rotation is produced, the rate of rotation corresponding very nearly to that of the field. When no work is being done by the motor, the synchronism is pretty nearly exact, and very little current passes through either the armature or the field. As the load increases, the armature tends to lag slightly, causing the passage of more current in proportion to the work done. The reaction between the armature and the field is similar to that between the primary and secondary coils of a converter, and the increase of load on the motor causes an increased supply of current in exactly the same manner as when lamps are added to the secondary circuit of a converter. This motor may be regulated in speed, and in-

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stantaneously reversed in its direction of running, without the use of switches or resistance coils, and the machine altogether seems to have many recommendations in the department of electric power. The pamphlet concludes with a description of the Westinghouse alternating central station at East Liberty, Pa., and with some very interesting "bits of experience." The East Liberty station has lamps running at a distance of 4¼ miles from the dynamo, and the plant has a capacity of about 8,000 lights. It is stated that the permanent market for light which is secured on the first canvass in towns of moderate size averages about one lamp to each eight inhabitants, and that with the station running the demand grows steadily and even rapidly to a limit as yet undetermined. Other conditions being reasonably favourable, the incandescent light can compete with gas, and at a profit, it is stated, when the price of coal per ton is not more than double the current price of gas per thousand feet when no meter is used; but with a meter and a motor service the electric current can be supplied at rates which, if met, must prove unprofitable to the gas companies.

At the meeting of the American Society of Mechanical Engineers at Scranton last week, Prof. Elihu Thomson's process of electric welding was brought under consideration in a Paper by Mr. C. J. H. Woodburn, and the reception accorded it was at once cordial and encouraging. Mr. Jerome Wheelock reported that he had tried the method on screws, and found that the lead of the screw was perfect without any change, while the strength of the metal at the welded point was beyond question as great as ever. Mr. Oberlin Smith had tried the process himself with excellent results, and said that there was not even as much fear of burning the metal as with the blacksmith's fire. It did its work more neatly and uniformly, under much better control, and with a great deal more cleanness. Mr. R. W. Pope spoke of the advantages of the method in setting up electrical circuits, and Mr. Woodbury mentioned a method of making electric welded chains by machinery, passing the rods into the machine, where they are cut, bent and joined, then welding the chain in a thorough manner, and passing it out at the other end of the device.

Among other recent happenings of interest I should mention the lecture last week on "Electricity in Sea Defence," before the Electric Club, by Lieut. Zalinski, and a meeting this week of the New York Electrical Society at Mr. Edison's laboratory at Orange, N.J., when Mr. A. E. Kennelly delivered an interesting address on "Electrical Measurements."

NOTES FROM PARIS.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *November 6th.*

The tenders for the lighting of the Halles Centrales have proved very numerous, no less than nine firms having tendered for the electrical plant and fifteen for the engine power. Among the former I notice the names of the Edison Company, M. Victor Popp (Thomson-Houston), the Société Lyonnaise (Brush), the Compagnie de l'Eclairage Electrique (Jablochkoff), and the Oerlikon Company of Zurich. Among the firms tendering for the engine and boiler power are Messrs. Belleville and Co., Babcock and Wilcox, Collet and Co., Boulet and Co., and Weyher and Richemond. All these proposals have been cursorily examined, and the general impression is that the £40,000 voted by the Conseil Municipal will certainly not be exceeded, and may not even be all required. A working sub-committee was immediately appointed, with instructions to lose no time in coming to a final decision, so that the works may be begun without delay. There is, therefore, every prospect that at the opening of the Universal Exhibition in May next the Halles Centrales and part of the streets around them will be lit by electricity.

The Syndicat International des Electriciens, of which M. Hippolyte Fontaine is the chairman, and which has contracted for the public and private electric lighting of the forthcoming Exhibition, has already fixed the number and position of the lights. The trees in the gardens are to be lit by 6,350 incandescents and the fountains by 104 arcs and 200 incandescent lamps, the Palais des Machines absorbing 346 arcs and 1,130 incandescents. The total will be no less than 1,300 arcs and over 10,000 incandescents, with an aggregate engine-power of 3,000 horse-power. The private lighting is expected to require another 1,500 horse-power at least. In these figures I do not include the 500 horse-power required for the lighting of the Eiffel Tower or the 300 horse-power for the gas engines. Great care will be taken in the fitting up of this colossal installation, and I have every reason to think that it will be one of the most perfect, if not one of the largest, in the world.

To intending exhibitors on your side of the Channel the proposed tariff of the Syndicat International des Electriciens may be useful. Fixing, maintaining, and lighting during the existence of the Exhibition 60fr. per 16 candle-power incandescent, 45fr. per 10 candle-power incandescent, 750fr. per 1,000 candle-power arc, 500fr. per 500 candle-power arc. These charges include the running of the conductors up to the lamps, the supply and renewal of the incandescent lamps, and the fixing, maintenance and renewal of the carbons in the case of arc lamps. These prices are calculated on the basis of a maximum of 900 hours, and will be charged even if this maximum is not reached. The money will be due, one-half on first lighting up and the second half three months after. After 900 hours the charges will be 4 centimes per 16 candle-power incandescent per hour, and 3 centimes per 10 candle-power incandescent per hour; while for arc lamps they will be 1fr. per 1,000 candle-power lamp per hour, and 75 centimes per 500 candle-power lamp per hour. All lamps will be extinguished after 11:30 p.m. The charges for current for motive power will be 50 centimes per horse-power-hour up to 500 horse power, and 40 centimes per horse-power-hour over that amount. The only two remaining regulations of any particular interest are the last clause and clause 7. The former provides that in case of disagreement between a consumer and the syndicate the matter shall in the last resort be referred to the Director-General of the Exhibition to adjudicate upon. Clause 7 runs as follows: "Should it happen that owing to *force majeure* the syndicate is under the necessity of temporarily cutting off the electric supply, the syndicate will not indemnify the consumers beyond repaying them the money collected for the supply they were unable to obtain."

The Palais Royal central lighting station is being actively pushed forward, and it is hoped that everything will be in its place by the end of this month at the latest. Considering the mass of earth to be excavated and removed, the rate of progress is certainly very creditable. When complete, the only sign of the existence of a central station in the Cour d'Honneur will be a magnificent candelabra, the light from which alone will suffice to illuminate all this portion of the building.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, Nov. 5, 1888.

A central station for electric light is approaching its completion, this undertaking being independent of the large central station about the erection of which the gasworks of the town have been for some time negotiating with the corporation. The new central station now in course of construction is being built by the well-known firm of J. E. Ericson's Mekaniska Verkstod, Stockholm, who already, in the summer of 1887, started a small station for about 350 incandescent lamps. Stockholm taking kindly to the new mode of lighting, an extension was soon deemed advisable, and the company bought a larger site, where a new building has now been erected. It was intended to open the new station on October 1st, but some unexpected difficulties in connection with the building, the foundation having to go to a depth of 22ft., have caused some delay. The floor of the cellar, where the whole of the machinery is located is 16ft. below the street. The new central station has a capacity of 4,000 lamps. The cellar consists of two compartments, of which one contains four compound steam engines of 100 horse-power each, and the other four boilers of a similar capacity. Both engines and boilers have been supplied by the Atlas Engineering Company, Stockholm. On the ground floor are four huge dynamos from Siemens and Halske, each with a capacity of 1,000 incandescent lamps. The room with the dynamos is just above the engine room, the belting passing through apertures in the arched stone floor, which rests on iron girders. On the first floor are offices and residence for the officials. On the roof of the building is a good-sized iron framework, for the support and fixing of the cables. The Ericson Company has recently sold the whole establishment to a new company, which has been formed under the style of Stockholm's Elektriska Belgsiringsaktiebolag, in which the old company, however, holds the largest number of shares. Subscribers for more than 2,000 lamps have already been secured, among them being the Crown Prince's residence at the Castle, as well as some of the principal reception rooms of the King and Queen of Sweden, several banks, Government offices, insurance companies, restaurants, &c.

The new building of the *Aftonbladet* newspaper has been fitted with electric light. The installation comprises about 140 16-candle incandescent lamps; the dynamo is from S. Schuckert, Nürnberg, with a capacity of 210 lamps, being, besides, able to feed an accumulation battery of 54 elements, which can supply current when the dynamo is not being worked for 56 16-candle lamps for 6—8

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hours. The dynamo is being worked by a two-cylinder high-pressure steam engine from Munktell's Engineering Company, Eskilstema. The regulating and coupling appliances, &c., for the electric light are most efficient, and the installation has altogether been effected in an able and satisfactory manner by the firm of Luth and Rosen, Stockholm.

The electric lighting at the Stockholm Telephone Company is about to be extended and a new boiler has just been fixed. It has been supplied by the Matala Engineering Company, and is to supply power for about a thousand lamps.

A large number of new installations in the provinces of Sweden are in the course of erection, both for the lighting of towns and on private premises. Among the towns which contemplate the adoption of electric light for street purposes is Linköping, where the gasworks are preparing a plan for the lighting of the town, and at Ostersund a private firm has taken the matter in hand. The Stockholm Elektriska Aktiebolaget is very busy at present, and among the places for which machinery is in hand may be mentioned Bergviks Wood Pulp Works; Blaukaholms Saw Mills; P. A. Blom, Arbaga; Boras Central Station for Electric Light; Brusafors Wood Pulp Manufactory; Falsterbo Bruk's dairy and other buildings; Falu Metal Extraction Works; Hjerpen Cellulose Manufactory, Iggesinid iron works, saw mills, and steam planing mills, Karlstad Engineering Company, Konga Wood Pulp Manufactory, Lilla Edet Wood Pulp Manufactory, Linköping Brewery, Linde Central Station for Electric Light, Mölnbaeka Wood Pulp Manufactory, Norrköping Weaving Company's Mills at Geyt, Olafström Steel Pressing Works, Stjarufors' Wood Pulp Manufactory, Strömsnäs Iron Works, K. A. Sundström, Lodberg; Sundleyberg New Engineering Company; Thurbo Wood Pulp Manufactory, Vesteros Gas Works Company's central station for electric light, and Vesteros Engineering Company. The dynamos for all these installations are made at the company's own works at Arboga, Sweden, under Venström's patent, and they have during the present year already delivered similar dynamos amounting to 400 horse-power.

Electricity has for several months been applied to tanning purposes in the tan goods of a Nordköping firm, Sweden, with very satisfactory results. By the new method the time required is being reduced; in some instances to the same number of days which it used to require months. Leather prepared in this manner is in every respect as good if not better than leather obtained by the old process, and the cost of manufacture is less. It appears to be the intention to extend the works.

The charge for inland telegrams in Sweden will, from the beginning of next year, be reduced to 50 öre (6⅔d.) for messages not exceeding ten words. A few additional alterations in the tariff will come into force at the same time. The charge for inland "press" telegrams will, as heretofore, be reduced to one-half; but the amount paid must not be less than 50 öre. For "express" telegrams the charge will after 1st January be three times the ordinary rate, whereas it only used to be double.

The Swedish State Telegraphs seem to watch the telephone movement with increasing jealousy, and show an inclination to interfere with the erection of new private telephone lines. This is the case with a private line which is being constructed between Stockholm and Vesteros, and which will probably have some difficulty in obtaining the necessary permission from the Government, if some excuse can be found for not granting it.

There are few, if any, capita's in Europe where electric light has made less headway than in Copenhagen. The Danes are in many respects slow and careful movers, but the principal reason for the long stagnation in electrical matters in the Danish capital is probably the fact that the corporation of the town own by far the largest and most important gasworks, so that the progress of electric lighting has been impeded through regulations the opposite of encouraging. To all appearances, a change is, however, impending, and the gasworks themselves are understood to be preparing a plan for electric lighting. In addition to this, the new company of Koefoed and Hanberg, Copenhagen, have applied to the corporation for permission to erect a central station in the principal square of the town, the area comprised in the proposed concession being the busiest and most central in the town. The Koefoed and Hanberg Company are, in this instance, co-operating jointly with the Allgemeine Elektricitäts Gesellschaft (Edison), Berlin, which arrangement ensures sufficient capital. Koefoed and Hanberg have also applied to the Theatre Royal authorities about including this large theatre in the working of their central station. Offers of electric lighting have also been made to the theatre by C. P. Jürzensen's electrical establishment, Copenhagen, in addition, I believe, to the heating and ventilation of the theatre. This firm has recently completed an installation at the Copenhagen Exchange. The motive power are two Otto gas engines of 12 and 8 horse-power, and the lamps number 140, averaging 16 candle-power. The switch-board is fitted with a safety contact, and everything has been done to ensure perfect safety.

CORRESPONDENCE.

ELECTRO-MAGNETIC WAVES AND THE PROPAGATION OF POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with the letters of Profs. Poynting and Lodge, which you print in your issue of the 2nd November, I believe that the following extract from a letter from Sir William Thomson (which I have permission to publish) will be of interest:—

"I don't agree that velocity of propagation of electric potential is a merely metaphysical question. Consider an electrified globe, A, moved to and fro, with simple harmonic motion, if you please, to fix the ideas. Consider very quickly-acting electroscopes B, B', at different distances from A. If the indications of B, B' were exactly in the same phase, however, their places are changed, the velocity of propagation of electric potential would be infinite; but if they showed differences of phase, they would demonstrate a velocity of propagation of electric potential.

"Neither is velocity of propagation of 'vector-potential' metaphysical. It is simply the velocity of propagation of electro-magnetic force—the velocity of 'electro-magnetic waves,' in fact.—Yours, &c., WILLIAM THOMSON."

Taking the second point first, it is, I think, clear that if by the propagation of vector potential is to be *understood* that of electric and magnetic disturbances, it is merely the mode of expression that is in question. I am myself accustomed to mentally picture the electric and magnetic forces or fluxes, and their propagation, which takes place at the speed of light or thereabouts, because they give the most direct representation of the state of the medium, which, I think, must be agreed is the real physical subject of propagation. But if we regard the vector-potential directly, then we can only get at the state of the medium by complex operations, and we really require to know the vector potential both as a function of position and of time, for its space-variation has to furnish the magnetic force, and its time variation the electric force; besides which there is sometimes the space variation of a scalar potential in addition to be regarded, before we can tell what the electric force is. Besides this roundaboutness, it implies a knowledge of the full solution, and if we do not possess it, it is much simpler to think of the propagation of the electric and magnetic disturbances, and I find that this method works out much easier in the solution of problems.

The other question will, I believe, be found to be ultimately of precisely the same nature. Start with the sphere A at rest, and the field steady, and consider two external points, P and P', at different distances. The electric force at them has different values, and the whole field has a potential. But now give the sphere a displacement, and bring it to rest again in a new position. Is the readjustment of potential instantaneous? I should say Certainly not, and describe what happens thus. When the sphere is moved, magnetic force is generated at its boundary (lines circles of latitude, if the axis be the line of motion), and with it there is necessarily disturbance of electric force. The two together make an electro-magnetic wave, which goes out from the sphere at the speed of light, and at the front of the wave $E = \mu v H$. Before the front reaches P or P' we have the electric field represented by the potential function, but after that it cannot be so represented until the magnetic force has wholly disappeared, when again we have a steady field representable by a potential function. It is difficult to see how to plainly differentiate any propagation of potential *per se*.

If the motion is simple-harmonic, there is a train of outward waves and no potential. I imagine that an electroscope, if infinitely sensitive and without reactions, would register the actual state of the electric field, irrespective of steadiness or not. By an electroscope, as this is a purely theoretical question, I understand the very simplest one, a very small charge at a point; or, say, the unit charge, the force on which is the electric force of the field.

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When these things are closely examined into, if the facts as regards the propagation of disturbances (electric and magnetic) are agreed on, the only subject of question is the best mode of expressing them, which I believe to be in terms of the forces, not potentials.

But there really is infinite speed of propagation of potential sometimes; on examination, however, it is found to be nothing more than a mathematical fiction, nothing else being propagated at the infinite speed.

It will be understood that I preach the gospel according to my interpretation of Maxwell, and that any modification his theory of the dielectric may receive may involve a fresh kind of propagation at present not in question.—Yours, &c.,

November 5th, 1888. OLIVER HEAVISIDE.

ELECTRICAL THEORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should have liked very much to consider and discuss the questions of Electrical Theory raised by Prof. Poynting and Dr. Lodge, but I am too busy at present to attend to anything that can be put off, especially when it is already engaging such competent attention. There is one point, however, I would like to make clear, and that is that I must have expressed myself unclearly if it was supposed that I thought that Hertz had demonstrated the existence of the ether. I thought I said clearly enough that it was the time propagation of light that did so, and that what Hertz had proved was that electro-magnetic phenomena were due to this same ether. Some are so familiar with this conception that they have forgotten that the time propagation in non-conducting space of electro magnetic effects had never before been demonstrated, and until that was done a theory of action at a distance was not only possible but was existent as a serious reality. This is more than can be said of such sceptics as Prof. Poynting's "very disagreeable person," who would probably maintain that the stars are the reflections of our sun in the irregular confines of the ether, even if he did not go so far as to maintain that all the rest of mankind are but reflections of himself. I doubt that either of these suppositions can be disproved.—Yours, &c., GEO. FRAS. FITZGERALD.

Trinity College, Dublin, Nov. 1, 1888.

MAGNETISATION OF SOFT IRON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The magnetometer employed by Mr. Tanakadaté in his valuable researches on the magnetisation of iron may be greatly improved for many purposes by winding a few turns of the solenoid circuit backwards round the magnetometer needle at such a distance as to just neutralise the field of the solenoid.

I have found this simple addition very convenient in practice, more especially when very small pieces of magnetic material are under test.—Yours, &c., SYDNEY EVERSHED.

2, Victoria-mansions, S.W., Nov. 6, 1888.

ELECTRO-CALORIMETRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If I rightly understand Messrs. Stroud and Haldane Gee's reply (*The Electrician*, November 2nd, p. 831), it amounts in substance to this:—Granted that the series arrangement is unstable, it is so over so small a range of temperature that under the conditions of experiment the error, if any, may be safely neglected.

Now I am perfectly aware that the series arrangement has been employed in several previous researches, and am, moreover, familiar with the substitution method; but it seems to me that the method, implying, as it does, a constant ratio of heating in the two calorimeters, assumes the wire to obey identically the same law of cooling in all the different liquids under comparison. In comparing the specific heats of water and oil I should anticipate that with, for example, equal power spent in the two baths the wire in the oil would require to be at a distinctly higher temperature than that in the water.

Let Messrs. Stroud and Haldane Gee shunt the two wires through a high resistance differential galvanometer, and they will obtain experimental evidence as to the truth or otherwise of the assumption of constant temperature.—Yours, &c.,

SYDNEY EVERSHED.

THE ETHER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The theory that ether is the medium of transmission for heat and electrical induction has been brought into great prominence by the recent important experiments of Prof. Hertz upon "electro-magnetic interference," the alternative theory of "action at a distance" being, as supposed, finally laid to rest. The great question now must be, what is the physical nature of this ether that is said to pervade all space? Can it be, like other matter, resolved into a collection of atoms, or does it consist of a homogeneous whole, without any break of continuity? If the former, then it appears to me that "action at a distance" asserts itself again, for we should have to believe that the transmission was due to some action *between the atoms* composing the ether, and it is immaterial, as far as the theory is concerned, whether the distance bridged be that between star and star or atom and atom, the variation in the two cases being simply one of degree. I should be very glad if others who have given this subject their attention, and who see the difficulty here expressed, would let me have the benefit of their opinion.—Yours, &c., W. P. GRANVILLE.

November 5, 1888.

TELEPHONE CALL OFFICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The date, 1888, given in Mr. Munro's letter as that of the establishment of the first London Call Office, is no doubt a misprint for 1883. This enables the question of priority to be definitely settled against London, since in 1880 there was a Call Office in Edinburgh, at Hall's Cab Office, Hope-street, as well as two in Glasgow, one in the lobby of the Royal Exchange and the other at 134, Douglas-street. By 1882 there was not a town worked by the National Telephone Company which did not possess at least one call office.—Yours, &c.,

A. S. T. E. and E.

[We are indebted to our correspondent for calling our attention to the misprint. The date should, however, have been 1880, not 1883. The call offices in London were opened in April of the former year.—ED. *E.*]

TELEGRAPHY WITHOUT WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Being very much interested in reading the account of Mr. Willoughby Smith's valuable researches in telegraphy without a metallic connection between ship and shore, I venture a few inquiries thereon.

In the experiment which Mr. Willoughby Smith describes in his letter, was the boat at sea an iron or wood vessel? and does an iron boat (such as are usuallyemployed for lightship purposes) give as satisfactory results as one composed of wood? I should have supposed that an iron vessel would tend to act as a derived circuit, and that, therefore, the signals would be materially less sensible than in the case of a boat made solely of wood, even if the copper plates be lowered right to the bottom.

I notice in the sketch of the experiment that the vessel was "end on" between the lines from shore. Would such satisfactory results have been obtained had she been "broadside on," with the surface of the plates correspondingly altered in direction?

Such changes of position would, I suppose, frequently occur in the case of a lightship.

I should also like to know whether the return signal "understand" was transmitted *electrically*. As far as I can gather at present it was not. In lightship telegraphy such signalling from the ship would, I take it, be even more necessary than that from the shore.

I have ventured these questions merely with a view to obtaining further knowledge on this very interesting and important subject, should Mr. Willoughby Smith find leisure and be disposed to supply it.—Yours, &c., CHARLES BRIGHT.

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TO THE EDITOR OF THE ELECTRICIAN.

SIR: In connection with Mr. Willoughby Smith's letter on the above subject in your issue of the 2nd inst., the following facts may perhaps be interesting to your readers:—

From this office—75, Queen Victoria-street, E.C.—we have an overhead telephone line to 59, Knightrider-street, a distance of about 110 yards. This line crosses several others nearly at right angles, but excepting a duplicate wire of our own which is not in use there are, at all events above ground, no parallel lines within considerable distance, and as the houses are high, underground wires, if any exist, are much too far off to produce any appreciable inductive effect, even if they were sufficiently parallel, which, owing to the line of the buildings, could scarcely be the case.

Under these circumstances it would be natural to expect that our line would be a quiet one and free from inductorial effect, but this is very far from being the case.

With a sensitive telephone receiver in circuit there is at all times a perceptible boiling noise, which is increased in wet weather, and is probably due to currents leaking from neighbouring wires—very likely at the insulators, some of which are on the same chimney as our own—and occasionally actual talking can be distinguished, though so faintly that only in very rare instances can the actual words be understood.

These constant noises are exceedingly faint, and can usually only be detected with sensitive instruments and acute ears. Not so, however, a very perceptible sound of peculiar rhythm which periodically occurs, and which under favourable conditions is loud enough to be detected with the telephone an inch or more from the ear.

When the line was first erected—about a year ago—I used to put down this peculiar sound also to leakage from neighbouring wires, and supposed that the regular rhythm was probably caused by one of the Exchange Telegraph Company's news printing instruments, with which very heavy currents are, I believe, employed.

Some time ago, however, an official of the General Post Office, who happened to call and who heard the effect, informed me that there would be no doubt that the sound was due to a Wheatstone automatic telegraph, as he could clearly detect both the plain reversals and the broken currents peculiar to that instrument.

Now, I understand that Wheatstone automatic instruments are only used by the Post Office, and that all the Post Office lines in the neighbourhood are underground and at such a distance from our line that induction could not possibly account for the loudness of the interference. It seems probable, therefore, that the effect would be due to an action similar to that which Mr. Willoughby Smith described, and that the sound we hear would be caused by a portion of the return currents of the Wheatstone circuit being diverted from the ground and flowing through our line, which is earthed at one end on the water main and at the other on the gas pipes.

Our wire being of No. 16 B.W.G. copper is of very low resistance, but the telephones employed have some thirty or forty ohms, and the resistance of the ground in the 110 yards intervening between our two earths must apparently be sufficient to bear an appreciable comparison to this, so that a small proportion of the Wheatstone current prefers to pass through our line and instruments rather than directly through the ground.

Considering the small intervening space between our two earths, and the probability that the distant earths of the Wheatstone circuit is many miles off—the General Post Office, where I presume the near earth is located, is some 300 or 400 yards distant in direct line—this result is certainly not a little remarkable.

I need only add that since we can always tell the moment the Wheatstone instrument starts or stops working, there would be but little difficulty in determining which particular instrument in the Post Office it is that we hear.

Of course the Wheatstone is too rapid to be read by sound, but the noise is I think quite loud enough to enable a skilled person to read the signals were an ordinary sounder with similar battery power substituted.

It appears to me that a great deal of what is now attributed solely to induction would be due to similar causes to the above, and that the subject is therefore well worth the serious attention of everyone connected with telephony.—Yours, &c.,

A. A. CAMPBELL SWINTON.

75, Queen Victoria-street, E.C., Nov. 6th, 1888.

RE BARNET ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your last issue that you have copied a report of the "Barnet Local Board" meeting from the *Barnet Press*. That report is not accurate. The amendment proposed was to refer the whole matter back to the Lighting Committee for reconsideration, and that committee, after a personal interview with our Mr. Joel, sent in an amended report advising that our simple undertaking to complete the permanent work in as short a time as possible, should be accepted. This amended report was submitted to a full Board last evening, and was agreed to.

Kindly insert the above to correct any erroneous impression that there is any difference or dispute between the Barnet Board and ourselves.—Yours, &c.,

HENRY F. JOEL AND CO.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of the members of this Society held last evening at the Institution of Civil Engineers, the President (Mr. Graves) stated that the question of changing the title of the society had practically been decided by the result of the circulars which had been issued, and which, as already announced, had resulted in an expression of approbation from 837 members, with only nine dissentients. He, therefore, would content himself with moving a formal resolution to the effect that the title be changed from the Society of Telegraph Engineers and Electricians to that of the Institute of Electrical Engineers. On this being put to the vote, it was carried unanimously.

The members then adjourned to the Hall of the Institution, and after the usual formal business, Mr. W. LANT CARPENTER, B.A., B.Sc.. read the following paper:—

On Ocean Temperatures in Relation to Submarine Cables.

About a year ago (November 10, 1887), a valuable Paper was read before the Society, by Mr. Stallibrass, entitled "Deep-Sea Sounding in Connection with Submarine Telegraphy."

In that Paper, and in the discussion which followed, scarcely any reference was made to what is now known as "Temperature Sounding," and as some of the facts revealed by this process appear to have an important influence upon the electrical condition of submarine cables, I venture to think that they may not be without interest to the Society.

Reserving for a little the description of the methods employed for ascertaining deep-sea temperatures, I may point out that the deep-sea surveying expeditions, commenced in 1869, of H.M.S. "Porcupine," "Shearwater," and "Challenger," of the U.S. steamer "Tuscarora," and of vessels belonging to other Governments, have shown conclusively that the temperature of the great oceans may vary from 85° F. at the surface to 30° F., or even lower, at the bottom, in the tropics; and that the bottom temperature of inland seas of the same depth, such as the Mediterranean, Red, Celebes and Sulu Seas, is often very much higher.

A submarine cable, therefore, is liable to be exposed at various portions of its length to a range of temperature between 85° and 30° F. Such a cable is liable to be affected in two ways by alterations of temperature—(1) the resistance of the copper conductor; (2) the resistance of the insulation. I believe that the capacity of the cable is but little altered by changes in its temperature.

A copper conductor having a resistance of 9 ohms per knot (sea mile) at 50° F. would have a resistance of about 8·6 ohms at 30° F., and of 9·6 ohms at 85°, the exact figures being

30°	40°	50°	60°	75°	85°
8·632	8·803	8·974	9·144	9·40	9·57

or the increase of resistance is between 30° and 85°—10·8 per cent. of what it is at the lower temperature.

I am informed that in the case of the extremely pure copper wire prepared by the new Elmore electro-burnishing process (by which a film is burnished during its electro-deposition) which has a conductivity of 102·38 per cent. of the usual standard for "pure"

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copper, the temperature coefficient is slightly higher than that given by Dr. Matthiessen for pure copper.

The insulation resistance is affected, however, to a very much greater extent, the exact figures being, in megohms per knot,

30°	40°	50°	60°	75°	85°
8085	4292	2308	1242	490	263

Hence the insulation resistance of a cable is more than thirty times as great at 30° F. as it is at 85° F.*

I hope that these figures will be considered enough to show the great influence of the temperature of the sea upon cables. I may add that all insulating materials are not equally affected. Thus, taking three cables, coated with different insulators, but each having an insulation resistance of 500 megohms per knot at 75° F., I am informed that at 28° F. the insulation resistance of gutta-percha would have increased to 12,850 megohms per knot, of Mr. Willoughby Smith's insulator to 15,200, and of Hooper's compound only to 1,590.

Although I do not propose to discuss the effect of the pressure at great depths, it may be as well to point out here, since the whole question of the effect of the sea upon the insulation resistance of a cable is under consideration, that Mr. Latimer Clark's formula enables this to be calculated, viz. :

$$R_p = R(1 + 0{\cdot}00023\,p)$$

where R is the resistance at atmospheric pressure, and R_p that at a pressure of p lbs. per square inch. An approximate datum for ascertaining this when the depth is known is that 800 fathoms depth gives a pressure of very nearly one ton per square inch.

Having thus shown the importance of a knowledge of deep-sea temperatures to the cable electrician, I will now describe the means adopted for ascertaining these temperatures. Prior to 1868 but very few isolated observations on this subject had been made, and the results were so remarkable that in many cases they were attributed to errors of observation. I believe that it was the present hydrographer to the Admiralty who first reported a bottom temperature of 31deg. in the Indian Ocean. The method of observation adopted was to fasten an ordinary self-registering thermometer to the sounding line, immediately above the machine which carried the detachable weight, to lower it to the bottom, and to read it when hauled up again, assuming that the lowest recorded temperature was at the bottom.

One reason why there was an inclination to reject the earlier observations was that they were inconsistent with the general idea propounded by Sir John Herschell in his treatise on Physical Geography "that in all deep seas a temperature of 39° F. will probably be found to prevail." This idea was founded on the assumption that sea water, like fresh water, attained its maximum density at 39 F. whereas, in reality, it continues to contract down to its freezing point, slightly below 28° F.

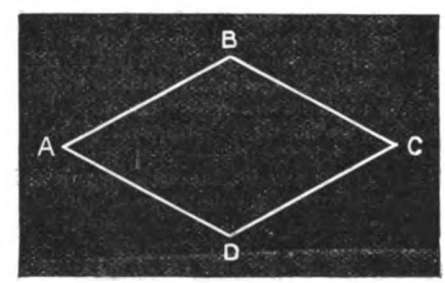
A real source of experimental error was, however, soon discovered ; the pressure of the sea at great depths, acting on the bulb of the thermometer, compressed it, and forced the liquid up in the stem, thus indicating too high a temperature. Several devices were proposed to obviate this ; the one finally adopted in 1869 being due to the suggestion of the late Prof. Wm. Allen Miller, admirably carried out by Mr. Casella, and hence the instrument is known as the Miller-Casella thermometer. It consists essentially of the ordinary Six's pattern of self-registering thermometer, but round the bulb is placed an exterior bulb, the space between the two being partly, though not entirely, filled with spirits of wine, a bubble of vapour being left. Numerous experiments made on shore with thermometers, with and without this protection, enclosed in iron boxes full of water, upon which hydraulic pressure to the extent of four tons per square inch was brought to bear, seemed to show that in this way the error due to pressure was eliminated.

In the spring of 1869 it was my good fortune to be a member of the deep-sea sounding and dredging expedition of H.M.S. "Porcupine," and to have, under Captain Calver, the first use at sea of these "protected bulb" thermometers. The general results I obtained were entirely confirmatory of those on shore. I prepared at sea a curve showing the differences of the indications between the protected and the ordinary thermometers, for a series of depths up to about 1,400 fathoms, and had the great satisfaction of being informed by Admiral Richards, who was then the hydrographer to the Admiralty, that this curve was exactly the same as one obtained on shore by means of the hydraulic press arrangement before alluded to. Since then these instruments have been most extensively used in deep-sea temperature sounding. Another form has since been constructed by Messrs. Negretti and Zambra, from suggestions kindly furnished to them by Commander Magnaghi, of the Royal Italian Navy. The neck of the bulb is contracted immediately above it, the contraction leading to a small reservoir ; the bulb contains enough mercury to partly fill the reservoir also. In using the instrument the bulb is in the usual downward position, and continues so until the sounding-line begins to be hauled up ; this reversed movement places the thermometer bulb upwards, the mercury breaks off at the contraction, and falls into what is now the lower part of the tube, when its length is measured on a scale, and the temperature at which its position was reversed is thus recorded. In deep-sea observations this reversal of position is effected by means of a fan working a screw, which releases the thermometer.

The Miller-Casella thermometer, however, from its extreme simplicity, is still largely employed in deep-sea observations in Her Majesty's Navy, and I am informed by the hydrographer to the Admiralty that the reversing apparatus of Messrs. Negretti and Zambra cannot always be depended upon in very deep water.

The "Porcupine" expedition, moreover, was supplied with a most ingenious device of the late Sir W. Siemens, for controlling electrically the results of the thermometric readings. I well remember my first introduction to him in the spring of 1869, to be instructed in the use of the apparatus, of which I was specially in charge. Through the kindness of Messrs. Siemens Bros. (Limited) I am enabled to show you the instrument to-night. It consists essentially of two coils of wire, similar in all respects, which form the two arms of a Wheatstone bridge. One of these is attached to a cable, and can be lowered to any desired depth in the sea ; the second, or comparison coil, being immersed in water on deck. The bridge is balanced, not by changing the resistances, but by altering the temperature of this water, and when equilibrium is obtained this temperature is read off by a thermometer, which is also the temperature of the submerged coil. Owing to the fact that the galvanometer furnished to us in 1869 was very far behind the beautiful marine galvanometer of the present day, it was only possible to make observations in exceedingly fine weather, when our small vessel of 400 tons was comparatively still.

To avoid the error which would be otherwise introduced by the leads to the resistance coil, the cable was constructed of a double core of insulated copper wire, protected by galvanised steel wire. One of the copper cores was connected to the arm B C of the bridge, and the other to the arm D C, and the steel wire served as the return earth-connection for both.



In the case of an instrument of this kind constructed for the American Government, and employed on board the surveying steamer "Blake" by Commander Bartlett, the resistance coil and comparison coil were made of silk-covered iron wire 0·15 mm. diameter, and each having a resistance of 432 ohms at 66° F. To allow the coil to be readily affected by changes in the temperature of the water, it was coiled on a brass tube with both ends open, allowing a free passage to the water. Sir William Thomson's marine galvanometer, with mirror and scale, were in this case employed to determine the balance of the bridge.

In a Paper by Sir William Siemens in the *Proc.* Roy. Soc. for June 15th, 1882, will be found the detail of a large number of comparisons, at various depths down to 800 fathoms, between the indications of this instrument and of the Miller-Casella thermometer simultaneously employed. The general result only is here given in Sir W. Siemens' own words :—

"The two instruments gave precisely the same readings at positions of maximum or minimum temperature, but in intermediate positions the electric thermometer, in almost every instance, gave a higher reading. This discrepancy may be accounted for, I think, by the circumstance that the electrical thermometer gives the temperature of the water actually surrounding the coil at the moment of observation, whereas the reading of the Miller-Casella instrument must be affected by the maximum or minimum temperatures encountered in its ascent or descent, which may not coincide with that at the points of stoppage. A strong argument in favour of the electrical instrument for geodetic and meteorological purposes has thus been furnished."

The physical, chemical, and biological results obtained by H.M.S. "Porcupine," in the North Atlantic, in the summer of 1869, and in the Mediterranean in that of 1870, were of sufficient interest to cause the fitting out and despatch of H.M.S. "Chal-

* I should add that these figures relate to the cable between Accra and Sierra Leone (African Direct Company), laid in 1886, and that Mr. H. D. Wilkinson has kindly assisted me in their calculation. The weight of copper in this cable is 130lb. per knot, which is also the weight of the gutta percha employed, and the sheathed deep-sea portion of the cable weighs 3½ tons per mile

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lenger," for a systematic survey of the great oceans, which lasted for more than three years. The expedition left Sheerness on December 7th, 1872, and returned to Spithead on May 24th, 1876, having altogether traversed a distance of nearly 70,000 miles, and having established at intervals as nearly uniform as possible along the course traversed 362 observing stations, at each of which the bottom temperature was accurately ascertained, while at most of them the thermal stratification was determined by "serial temperature" soundings. The vessels of other Governments have also contributed a good share of observations.

The work of the United States ss. "Tuscarora," Commander George S. Balknap, however, deserves special notice here, because she was sent out by the United States Government, not with a view to scientific research, but for the purpose of determining by deep-sea sounding the most practicable route for a cable between the Pacific seaboard of the United States and Japan. In addition to the ordinary bathymetrical determinations, bottom temperatures were everywhere taken with Miller-Casella thermometers, and the thermal stratification was also determined down to about 600 fathoms by serial soundings. A very important body of facts was thus collected in regard to the thermal condition of the North Pacific along the two lines examined, viz., the southern route, passing directly across between the parallels of 20deg. and 30deg. N. lat. from San Diego, in California, by way of the Sandwich Islands, to the Bonin Islands, and thence north to Yokohama; whilst the northern route followed a great circle course from Yokohama along the line of the Kurile and Aleutian Islands to Cape Flattery, the northernmost point of the United States territory. Here such great depth of water, over 4,600 fathoms, was met with, having a bottom temperature of 32deg., that it was then deemed (1874) an impracticable route for a cable. During this cruise no fewer than 483 casts of the deep sea were taken, and the results were plotted in the same manner as those of the "Challenger," and embodied in a systematic account of the work, issued by the Hydrographic Office of the United States Navy, a copy of which I have here. The general result of all such observations, as regards the distribution of temperature in the open ocean, contrasted with that of seas more or less landlocked, such as the Mediterranean, I will now very briefly summarise.

By attaching thermometers to various points of the sounding line or wire it is possible to ascertain the temperature at various depths below the surface, as well as on the bottom. Such a set of observations made vertically over one spot is called a serial temperature sounding. The results of a number of such observations may be plotted upon a "Temperature Section," constructed upon two scales, a horizontal one of nautical miles, and a vertical one of depths in fathoms. The lines, more or less inclined to the horizontal, which are drawn through points of equal temperature, may be conveniently designated bathymetrical isotherms. In the diagrams before you the differences of temperature are indicated by coloured bands, as well as by lines—blue in various shades indicating water below 40°F., green and purple being used for water from 40° to 65°, while warm water is shown by various degrees of pink. [Diagram shown.]

I will call your attention first of all to these temperature sections across the North Atlantic, from Madeira through the Azores and Bermuda, to Halifax, Nova Scotia. You will observe, in the first place, that about two-thirds of the whole of this mass of water is 40°F., the bottom temperatures ranging from 34°·8 to 38°·7. You will also notice the *extremely* small bulk as shown by its sectional area of the true "Gulf Stream," *i.e.*, the superheated surface-laying of water issuing from the Gulf of Mexico, and, lastly, you will notice the continuity of the "cold wall" long known to the United States coast surveyors with the cold deep water of the Atlantic basin. This continuity was first traced, and the explanation of the phenomenon afforded, by H.M.S. "Challenger." In this diagram of the North Pacific, you will observe the same general condition of thermal stratification prevailing, but that there is a much larger proportion of colder water, and the bottom temperatures are even lower. In the next place, let us notice the facts in the equatorial Atlantic, where you will observe that the colder water comes nearer to the surface than anywhere else, and as the surface temperature is extremely high, the rate of fall in temperature is very rapid, and the isothermal bands are very narrow.

Speaking generally, these are very fair examples of the thermal stratification of any one of the great oceans, whose communication with the others is unrestricted, not only at the surface, but also to great depths below. But now let me ask you to compare with these diagrams some which represent the thermal stratification of such seas as are more or less landlocked; and as a good example we may take the Mediterranean, on the bottom of which so many cables lie. You will observe that, for the first 200 or 300 fathoms, the temperature falls in proportion to depth, in much the same way as it does in the Atlantic outside the Straits of Gibraltar, but that after that point, about 54° F., there is no further fall in temperature, notwithstanding that depths of 2,000 fathoms are reached, at which, in the Atlantic in the same latitude, and only a short distance west of Gibraltar, the temperature is 36deg. We shall presently see reason to believe that in this and similar cases two factors are concerned in the result—first, the average winter temperature prevailing in the locality; second, and most important, the depth to which there is free communication between these partially landlocked seas and the open oceans. In the case of some of these—the Red Sea, for example, whose only communication with the great oceans is through the shallow Straits of Babelmandeb—the mean winter temperature, or isocheimal, of the surface water has a considerable influence in determining the bottom temperature at great depths. The lowest temperature of this surface layer, even in its most northern part, is 71deg., and this temperature is uniformly carried down to the bottom at 450 fathoms depth. I am not aware of many deep-sea temperature observations, beyond those of Sir George Nares in the Gulf of Suez, having been made; but it may be pretty certainly affirmed that no lower temperature than this will be found, even on a bottom exceeding 1,000 fathoms depth, since the lowest surface temperature in the southern portions is never below 75deg., the highest being nearly 90deg. Yet, in the Arabian Gulf, the temperature at a depth of 2,000 fathoms is not above, and is very probably below, 36°·5.

A similar contrast is shown by the temperature soundings of Commander Chimnius between the temperature of the Sulu Sea (a small area between the N.E. of Borneo and Mindinao) and of the China Sea. The former, though only partially landlocked, is so shut in by reefs and shoals as to have only a very superficial and limited connection with either the China Sea or the Celebes Sea. Notwithstanding this inclosure, the depth is very great, ranging to 1,603 fathoms, and the following bottom temperatures, taken along the line of the submarine cable between Singapore and Hong Kong, make this point very clear:—

Sulu Sea.		Depth.		China Sea.
83°	.....	Surface	.....	84°
—	.....	30 fathoms	.....	77°
—	.....	50—80 ,,	.....	71°
64°·5	.....	100 ,,	.....	—
—	.....	200 ,,	.....	51°
51°·5	.....	308 ,,	.....	—
—	.....	416 ,,	.....	41°
50°	.....	500—1,603 ,,	.....	—
—	.....	673—1,546 ,,	.....	37°

The Sulu Sea was also examined very carefully by the "Challenger," in its relations to both the China and Celebes Seas. From 82deg. at the surface the fall is rapid to 60deg., but the isotherm of 55deg. lies at about the same depth as the isotherm of 50deg. in the China and Celebes Seas; below this the fall is still slower, so that the minimum of 50°·5 is only reached at 400 fathoms, from which depth to the bottom, at 2,550 fathoms, the thermometer continuously indicates 50°·5. Hence the condition of this sea closely resembles that of the Mediterranean. The influence of a still less complete seclusion from the polar under-flow is shown in the Celebes Sea, where the bottom temperature at 2,667 fathoms depth is 38°·5, while at nearly the same depth in the Indian Ocean, a little to the west of Sumatra, the bottom temperature was 32deg.

Again, a "Challenger" sounding between New Zealand and the Fiji Islands gave 32°·9 at 2,300 fathoms depth; but further west, towards Raine Island, at the entrance of Torres Strait, where the depth ranged from 1,350 fathoms to double that, the temperature never fell below the 35°·1 found at 1,300 fathoms depth, "which proves, undoubtedly," says Sir George Nares, "that below this depth the sea is cut off by a surrounding ridge, over which the greatest depth of water of any channel through it is 1,300 fathoms. As this is about the depth we found between the New Hebrides and the Fiji Islands, we may take it for granted that from Sandy Cape, in Australia, to New Caledonia, the New Hebrides, the Solomon Islands and New Guinea, there is a shallow bank with not more than 1,300 fathoms depth of water. Below this depth, in the hollow between the New Hebrides and Torres Strait, the water is comparatively stagnant, as in the Mediterranean and other cut-off seas."

What is the explanation of these remarkable facts, facts which have been verified over and over again, at various seasons of the year? The most probable one I believe to be (and there is much biological evidence in its favour as well as physical) that a constant vertical circulation of the waters of the great oceans is going on, sustained by differences of specific gravity, which are due, in the main, to differences of temperature. This doctrine was accepted by Sir John Herschell only three weeks before his death, and was also formally referred to by Sir George Airy in his Presidential Address to the Royal Society in 1872, as "certain in theory, and supported by observation." Speaking generally there is much evidence to show that in the Atlantic, Pacific and Indian Oceans the upper portions of the water in the northern hemisphere are moving in a north-easterly direction, while the lower layers are as constantly moving in a south-westerly direction. One very curious fact in support of this last assertion,

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and of especial interest to us, is given in the *Proc.* Roy. Soc. for 1870, Vol. XIX., p. 218. A buoy which was attached to the Atlantic cable of 1865 broke away from the bulk of the cable, but carried with it a great length of the wire rope to which it was attached. Although the surface drift would have carried the buoy north-east of the spot where it was first floated, it did actually travel a long way to the southward, owing to the action on the surface of the long length of cable attached to it of the lower layers of water.

This great vertical oceanic circulation, then, is an illustration on a gigantic scale of the convection currents in liquids, with which we are all familiar in the hot water circulatory systems in use for heating public buildings. In the case of the ocean, however, there is reason to believe that the polar cold, at the surface, rather than the equatorial heat, is the prime cause of the movement. Into the discussion of that question, however, I must not enter here.

If this theory of a general vertical oceanic circulation be accepted the explanation of the phenomena presented by land-locked seas becomes at once apparent. They are more or less cut off by the surrounding barriers from this general circulation, and hence only receive a limited portion of the colder water. Thus, to take the case of the Mediterranean. The greatest depth of the Straits of Gibraltar (its only communication with general oceanic systems) is about 200 fathoms; the temperature of the North Atlantic outside at that depth is about 54deg., and hence no colder water than that can find its way into the Mediterranean, and accordingly in that sea we nowhere find a lower temperature than 54deg. The same explanation applies, with variations in depth, to the other cases I have mentioned in the Indian Ocean and elsewhere, and in many of these instances coral reefs appear to be the barriers which cut off the cold water supply.

The theory affords a reason, also, for the fact that under the equator the colder water is nearer to the surface than anywhere else in the tropics or sub-tropics. Here the two streams of polar water meet, the Arctic and the Antarctic, and owing to this a double volume of cold water is present, which wells up to the surface quite rapidly. I may mention that this point was foreseen and predicted by the proposers of the theory, before the observations were made; and subsequently these latter justified the expectations formed. There is, therefore, a continual ascent of glacial water under the equator; or, as has been well said, there is under the equator a belt of water which is colder than the water to the north and south of it.

It would be very interesting to trace the effect of this great system of oceanic circulation upon climate, and to discuss the evidence for its existence. Our Society, however, does not concern itself with such matters, and I must forbear. I have striven to lay before you, in very brief outline, the general facts of the distribution of temperature in the sea, and especially on the sea bottom where our cables lie, and to point out the influence of these temperature conditions upon the cables themseves. I venture to hope that those members who have special knowledge with regard to the influence of temperature upon cables will give us the benefit of that knowledge in the discussion which I trust will now follow.

An interesting discussion followed, in which Mr. Alexander Siemens, Mr. Chas. Bright, Capt. Wharton, and others took part. A full report will appear in our next issue. On the motion of the PRESIDENT, a cordial vote of thanks was passed to Mr. Laut Carpenter for his valuable Paper.

NOTE ON GEARING FOR ELECTRIC RAILWAYS.*

BY MR. ALMON ROBINSON.

Probably no one will be disposed to deny that in devising a connection for the motor and the car wheels, what Mr. Sprague attempted to do has been done extremely well. Has he attempted all that is desirable?

Mr. Sprague's investigations have shown that in street car work a very large percentage of the whole power used is expended in starting the cars. Now, it seems to me that a motor whose speed has a fixed ratio to that of the car wheels must work uneconomically when the car is moving slowly, for no amount of skill spent in varying the magnetic circuits can prevent an armature from wasting a current sent through it when it is practically standing still. It would seem, therefore, that wide variations of speed and load would make it necessary at times to weaken the field to an unprofitable extent. Perhaps, however, Mr. Sprague may be able to show that a properly designed motor will work with a high efficiency in doing anything which he puts upon it in railroading. But even in that case there would still remain the extra cost and extra weight of a motor large enough to lift its heaviest load by a dead pull. To do the hardest part of his work Mr. Sprague is really using a thing in which he disbelieves—a slow-moving motor.

In the storage car problem this matter of weight and bulk and cost becomes the most important element. Here the present practice is simply the hauling about of ten men to do by main strength what one man could do by a lever.

The desirability of a variable leverage for the motor has not escaped the attention of experimenters. In Mr. Henry's Kansas City work an arrangement of toothed gearing and clutches was tried. I have never learned whether this particular feature proved a help or a hindrance, nor whether it is in use on the Henry road said to be running at San Diego, Cal. A prominent inventor has expended a good deal of ingenuity on the details of a plan, making use of reciprocating friction pawls. Mr. Reckenzaun tried and abandoned a leather-covered chain clamped between two cones in such a way that the diameter of the circle of contact could be varied.

Mr. Van Depoele has suggested, and, I presume, tried, a connection having two different speed ratios, in which friction gears were used. For this particular purpose (furnishing a variable speed ratio) I am obliged to confess myself a believer in the possibilities of frictional gearing. For electric railroad work it is certainly under a cloud at present. Those who have used it most like it least. The eminent engineer who, about a year ago, read a Paper before the Institute on "Methods of Gearing," seemed to consider that it had been sent to its last resting place by the experts who tested some of Prof. Fleeming Jenkin's devices.

No one seems to notice that every day and on every railroad this method of transmission gets the roughest possible testing; that every locomotive pulls its train by frictional adhesion; that a rail and driving wheel are neither more nor less than a frictional rack and pinion. When we try to copy the work of the locomotive under other conditions our troubles begin; but no man who has ever seen a freight engine climb a grade has any right to speak with disrespect of frictional gearing.

The real root of all the difficulties with frictional transmission seems to be that the pressure producing adhesion does not vary with the dimensions of the gearing, so that when we reduce the size and increase the speed of the gearing the friction at the journal bearings soon becomes enormous. For light work this is partly obviated by using, instead of metal, some more adhesive material, such as paper, raw hide, &c. But none of these surfaces will stand a pull at all comparable with that on the surface of a locomotive driving wheel.

The most promising methods would appear to be those in which the pressure is prevented from acting across the bearings. This idea is carried out to some extent in the well-known V-grooved gearing, but the unavoidable sliding and grinding of the surfaces makes it impossible to obtain a high duty from it. The idea is more fully carried out in the devices of Sellers, Jenkin and others. I do not know that anything has been suggested—I certainly cannot suggest anything—which does not leave, for the purpose under consideration, much to be determined by trial. Knowing well the effect which actual trial is apt to have upon untried devices, I cannot blame an engineer who prefers to let well enough alone, if a fixed speed ratio is all that he cares for. But I cannot help thinking that a usable connection, which left the speed of the motor independent of that of the car, would be a valuable acquisition; and that a probability of obtaining it would amply justify further experiments with methods of gearing.

DISCUSSION.

[The discussion which follows relates both to the above Paper and to Mr. Leonard's Paper on "Some Objections to Overhead Conductors for Electric Railways," read at the same time, and reported in our last week's issue.]

Mr. ELIAS E. RIES: Mr. Sprague deserves to be congratulated upon the ability and thoroughness with which he has presented the subject, and I take pleasure in adding what little I can to the discussion of such of its features as it seems to me require more elucidation. A matter of considerable importance is whether one or two motors are most advisable for street car work. I myself am in favour of employing but a single motor directly geared to both axles, and it is the universal opinion of electricians and engineers that in a case of this kind a single large unit is better than two or more smaller ones, and this is especially true in regard to street car motors. A great deal has been said about the difficulty of making satisfactory connection with both axles from a single driving source, but this can be overcome, and I may say I have devised a method of doing this which avoids most of the difficulties heretofore encountered. It is a question to my mind whether Mr. Sprague's assertion that independently-driven axles necessarily give better track adhesion can be sustained; in fact, it seems to me that the reverse is generally the case. There can be no doubt, as Mr. Sprague states, that independently driven axles will slip until they get the best grip, but it is also known that a slipping wheel, or pair of wheels, will readily continue doing so under the influence of the acquired impetus and the rotative strain exerted upon them by the motor. However, in ordinary street cars the load is constantly shifting from the forward to the rear axle, and *vice versâ*, due to the lurching of the car and unequal distribution of the weight or load. Therefore, supposing a car to be slightly overcrowded at its rear end, the forward wheels must necessarily slip, and the motor driving them will run light for the time being, leaving the rear motor, which was designed to do but half the total work, to do it all, and subjecting it to an enormous electrical and mechanical strain. I have given this subject considerable attention, and have come to the conclusion that for street cars of ordinary construction the axles should *not* be independently driven, but should be directly connected with each other, preferably through the armature shaft of the motor itself, whose weight is equally borne by both axles. One thing that struck me as very peculiar in connection with the Richmond road, was that an electrical engineer of Mr. Sprague's ability and experience should so utterly abandon all measure of precaution for the safety of his passengers and the public at large as would seem to be indicated by his employment of the track rails and ground as one side of the circuit instead of using a

* Paper read before the American Institute of Electrical Engineers.

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double overhead conductor. This is the more to be wondered at when it is shown by Mr. Sprague's own description of the elaborate and extensive means employed for connecting the track rails and reinforcing them by separate wires to insure perfect connection with one another, and with the ground pipes, &c., that aside from its danger, this plan is considerably more expensive than a second overhead wire and double trolleys would be. I can only explain this action on the part of Mr. Sprague by asuming that he has found the track return necessary to enable him to ascend the steep grades of the Richmond road by reason of the increased tractive adhesion obtainable, due to the passage of the propelling current from the wheels into the rails. If my memory serves me rightly, it was not very long ago—in his address before the American Street Railway Association at their Philadelphia convention last October—that Mr. Sprague stated that on roads having grades of more than 6 per cent. he proposed to attach a hill horse to the motor car. Whether he intended this as a parting tribute to the usefulness of the patient and long-suffering car horse who has so faithfully served the public I do not know; but at all events, he stated that he did not believe it possible for a self-propelled car to get up the hill in any other way. This was some time after I had announced the results of some experiments I had made,* both with the electric current and electro-magnetism, in which I was able to show and demonstrate that the tractive adhesion of driving wheels could be very largely increased by these means, sufficient, in fact, to enable a motor car to ascend a grade much steeper than any yet surmounted. I may say that we are at present engaged in applying this system to an ordinary steam locomotive, on a prominent railroad, and if the results obtained prove to be anywhere near what we have reason to expect from certain experiments made on a smaller scale, I shall hope to be able to show you a very decided increase in its pulling capacity, and to effect a considerable saving in the cost of operating the road.

Mr. F. J. SPRAGUE: I am rather glad that some argument has come up in the discussion of the Paper. We use in Richmond a double commutator machine, which is unknown to-day to anyone except those whom I have taught. Its plan of winding has never been published or described. It is, as I say, unknown except by the *employés* of my company, and if there is any question as to the similarity of that winding to some other I have not the slightest objection to giving the necessary diagram of connections. It is a series machine, but a series machine which has some peculiar characteristics. It is wound with three sets of coils, and the peculiarity very largely consists in the methods of connecting and certain switches, by which the coils in these machines are commutated and reversed, their field magnetisation and their current varied at will, through progressive changes, by means of which, when desirable, we are enabled under various loads to maintain an almost absolutely constant field, while the current may vary 300 per cent. That has never been done with a motor before; that is, to so regulate the field that, with a variation of 300 per cent., a perfectly constant field will be maintained. This field connection is somewhat peculiar, so much so that it would be useless for me to attempt to describe it now, although I shall take occasiou to publish a description of it in the near future. There are, however, some characteristics of motors other than the mere winding of the armatures or fields, or their regulation, which are essential for street car purposes. It is, as Mr. Mailloux says, a question partly of proportioning, partly of calculation, a putting together of those things which you have at hand to meet those conditions under which you have got to work. Two years ago, I think I may fairly say, such a problem as equipping the Richmond-road, with its abnormal conditions, with the circumstances of manufacture which we had to meet, and in the time that was given to us in the undeveloped state of this art, would have been looked upon as something preposterous. I am frank to confess that had I known what I had to go through, I would, perhaps, have had neither the necessary courage, time nor patience, or have cared to have risked the money which I did. I have spent in Richmond $150,000, and I have learned something. While I do not care to state all I learned, I have taken advantage of it in our future work. A great many of the principles of regulation that have been associated with my name are not characteristic of the Richmond machines. They are designed for other purposes. Now, referring to Mr. Leonard's Paper, a great many of the deficiencies he speaks of exist in Richmond, and unless the machine were of superhuman design, they must exist there. A year ago those machines were put in in a great hurry; the maximum normal capacity that they ought to run at is about seven and a half horse-power. Very frequently they have been called upon to develop ten or eleven horse-power, an increase of about 50 per cent. In the nine months during which this road has been in actual operation, and it has run nearly half a million of miles and carried millions of passengers, not one working car has ever been inside of a closed shed. They have been "housed" in the street. They have run without covers of any kind or character. They have run with six inches of water in the street and brake-beams running in the water, which was splashing on the motors. They have run until you could not tell what the machine was; until the accumulation of mud and oil and filth was of such a character that no other piece of machinery in the world would ever have run. I am not responsible, unfortunately, for the management of the Richmond railway. If so, we would not have the possibility of a number of cars lying in the car shed, so called, unfit for duty, after having been left in the streets during ten days of rain. The report from one of my own inspectors less than one week ago was that there was no more trouble in running a 40-car road by electricity than in one operating three or four cars. He is a level-headed, practical, cautious man, not given to strong statements, and very conservative in what he says or does. Within the next thirty days or so we will have that machine out, and we will put one of those armatures that people have laughed about inside a barrel of water for twenty-four hours, and we will take it out and we will run it.

* See *The Electrician*, Nov. 4, 1887, p. 537.

The breaking of a trolley wire, sometimes caused by a trolley catching in it, can be, of course, almost entirely obviated by one or two precautions; one of these is the non-use of solder in the erection of a line. In putting up the Richmond line we used hard-drawn copper. Hard-drawn copper as it comes out of the mill has a remarkable tenacity, but when it has been handled, and when under the heat of a soldering iron it has been warmed up, you reduce it practically to the strength of soft-drawn copper; so that you will have at the point where solder has been applied a weak spot which entirely nullifies all your other precautions. In our future work this trouble will be entirely removed, because we will not use solder from one end of the line to the other. The use of silicon-bronze or aluminium-bronze drawn for high conductivity and great tenacity will likewise render less possible any accident due to the breaking of the wire. This wire can be drawn of from 100,000 to 150,000 pounds tensile strength to the square inch, and, being put up without solder, I can see little possibility of that wire ever coming down.

So far as the use of poles is concerned, I believe I said in my recent Paper that the objection to overhead wires was entirely reasonable, because people did not put money enough into them. On a new road, where I can make my own conditions before the contract is signed, I am willing to put in just as expensive a road as is desired. Instead of putting in wooden poles in Boston we are putting in iron poles tested up to 1,400 pounds. Instead of setting them in clay we set them in concrete. Those poles will not come down. So far as the span wires are concerned there is no danger of their breaking. As to the use of a single overhead line, that, I know, is a much discussed question. But I find the practice of most people is a single overhead line.

A criticism has been made about the use of two machines on a car. I have spent half an hour trying to get the length of this room with one motor on a 6 per cent. grade, under a condition which happened to give a slimy surface on the rail, and I have seen under the same conditions, on a 10 per cent. grade, on a worse track, two motors handle the heaviest loads. It is not merely because the wheels can get a better grip—you have got your total weight available for traction. The forward wheels can also in case of emergency travel faster than the rear wheels. That has been done, even on a level, and has the advantage of breaking up whatever obstructions there are on the track, and leaving the track perfectly clear. If you put between your wheel a broom or brush you have excellent traction. It could not be done by gearing both wheels to the same motor, simply because you could not get that independence of grip that is necessary. Running both pairs of axles requires certain devices, the use of which, in view of existing street car practice in the matter of constructing running gear, I do not think is advisable. There are some 40,000 or 50,000 cars in the United States, and there are one or two settled principles in them; one is, perfectly independent action of the axles. No four wheels on a car are of the same diameter; they are never cast absolutely alike; they do not run necessarily on the same tread. Any difference in the level of the streets will send the weight of a car down on one side. In fact, it seems to me, in the face of all I have seen, almost trivial to make any objection to the independent driving of the two axles. I admit it is cheaper to build one machine to put on a car, but you can build two smaller machines of the same capacity. Space in a street car is a matter of considerable importance. You want to get large power on a car to handle heavy loads, but you have got to have it in comparatively small space.

As to keeping a trolley on a wire, I am quite willing to enter into a contract to put a trolley on a car which never can come off the wire, and, in fact, some of our cars are now running with one man, and have to run with one man, simply because the railroad people will not pay an additional conductor.

The methods of getting rid of troubles have been, of course, subjects of a great deal of study. It was not possible a couple of years ago to look forward and face all the conditions that arise in practice. We electricians did not know enough about street car practice, and street car men did not know enough about electric railways, so we had to join hands with the street car men, and we had to put the cars and motors into the hands of ignorant men, and meet those difficulties in order to know how to get over them. I think I may safely say that the road we put in sixty days from now will bear about as little resemblance in details to the Richmond road as it is possible for any two roads to bear to each other, simply because of great improvements, not only in the motors, but in the gearing, switches, trolley work, and all overhead superstructure.

A two-wire system requires from two to four times the weight overhead. Where we put a main conductor alongside of the street and reduce the trolley wire to a single one, a fifth of an inch in diameter, that enables us to keep our structure in position a good deal better. So far as safety is concerned, the fact that a horse was killed in Richmond in the early days of running is no criterion of it. Two wires are more liable to come down than one; but you will not get killed with 400 or 500 volts. I have several times taken that potential myself. We do not know whether the horse that was killed in Richmond broke his neck or was killed by electricity. He was boiled in order to get his skeleton; he did have a broken neck; it is not known whether that killed him.

As far as the use of the storage battery is concerned, I am just as anxious as anybody else that the storage battery should be a success. But it will never get on a car in Richmond when they have got to put 4,000 pounds weight on that car. They never will take 20,000 pounds weight up a ten per cent. grade with a storage battery until it is in a good deal higher state efficiency than it is to-day. We have, although not prominently connected with storage battery work, been experimenting for a long time. We keep a car on tap. We have had hundreds of plates built in the past year, trying to devise some means of overcoming the difficulties that exist in

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storage batteries. We hope to have a normal capacity of discharge in, say, a 35-pound cell of not less than 75 or 80 amperes, and that they can stand 150. The resistance ought to be about one-third or one-fourth of the present storage battery. The plates will be practically indestructible; and, finally, it will not be a Faure cell. That is the sort of thing I am looking for. I no not know whether we will get it. The results, so far, have been very encouraging, but we never will attempt to climb a 10 per cent. grade with it, and we never will put it on the market until we know it is satisfactory. We will do our own experimental work. We expect to get the battery down so that not more than 1,800 pounds is necessary to handle the car under ordinary conditions. I think by the time the Boston road is running, which will be in about five or six weeks, if Providence is not against us in the matter of the weather, we shall be able to show such improvement in the overhead line, as to its efficiency, economy, and appearance, the character of the motors and the work which they will do, as will be a subject for mutual congratulation.

Mr LYNE: There are one or two remarks made by Mr. Leonard that I would like to refer to. The devices, so far as I have been able to discover, in transmitting the power from the motor to the shaft of the car or axle of the car, have been in many cases obsolete devices. For instance, the grooved friction wheel has been used on the "Ben Franklin" that was tried on the Ninth-avenue road. That device was condemned by engineers years ago, because the friction wheel caused flat places. If a sufficient pressure was not brought to bear on these wheels to bring it up to the maximum point at once, the surfaces would slip on one another, and the grooves would have a flat place. When the Fontaine locomotive came out we were led to believe that the whole railroad system of the country would be revolutionised in a few months by that engine. A certain few predicted its utter failure, and it failed, principally in consequence of the tyres getting flat places on them. As soon as they did get a flat place they began pounding themselves to pieces, and the result was a dismantling of the whole affair. We know that the same occurs in locomotives in climbing grades. They slip, get flat places, and then the wheels have to be turned off, or the tyres rather.

Mr. SPRAGUE: The question of depreciation of line is a question of construction very largely. It is certainly not a question of wear. A consideration of the actual time in which a wire is in contact will show this. With cars that are making two minutes headway and running seven miles an hour, with a round trolley wheel, making contact on a round wire, we have almost a line contact, but call it an eighth of an inch contact. Any portion of the wire is in actual contact with the wheel less than one two hundred thousandth-part of the time; in other words, in continuous current contact, not over one hour in twenty-six years. Consequently, the current ought not to rapidly wear the wire out, and it does not. In fact, the period in which any particular part of the wire is in contact is not over one two-thousandth part of a second when the car is moving seven miles per hour.

The question of insulation, leakage, and lightning came up a little while ago. It is a remarkable fact that lightning does not necessarily follow always the single overhead wire. We have had in Richmond quite a number of cases of the line being struck by lightning. Our ground circuit is made by three paths; two through the boilers and water connections, and a third by a covered wire running about 1,000ft. on poles out, and directly down, to the track. We have had lightning come over that wire several times, and the statement of the engineers is that it is about an even thing whether it comes in on that line or the other one. It terminates in a well. So far as the leakage is concerned on that line it can easily be reduced to an average of one-tenth or one-hundredth part of one per cent. It has never been sufficient to cause the slightest interferenc with the operation of the wire except in the case of the short circuit. If existing, it can very easily be perceived by taking the reading of the ampere meter. The leakage is nothing so far as loss of power is concerned.

Mr. D. E. LAIN: About the only part of the matter I wish to speak of now is the means of coupling the motor to the axle. In Mr. Sprague's excellent Paper he compares the method of direct coupling with the others, coupling by means of chain gear, friction gear, &c., in a way which, I think, was rather hard on the direct coupling. I have had some experience with some of these ways, and it seems to me that the method of direct coupling offers certain advantages which no other method offers. The easy motion and perfect noiselessness of the coupling certainly place it ahead of any other means. The simplicity, of course, in this method, is greater than in any other. All the details are reduced to a minimum. The objection, of course, is that on account of the slow speed at which the armature must necessarily run—running no faster than the driving-wheel—a larger machine is necessary. This may be an objection, and may not. In street railway work, where certainly not more than ten horse-power is required, where the whole equipment should not weigh more than, say, 5,000lb. when the car is loaded, the weight of the motor enters as a part of the whole weight; with the weight of a direct coupled motor, that is not of such great importance after all. If the drivers be reduced to, say, 18in., or thereabouts, a motor can be built that is not necessarily over 25 per cent. greater in weight than one using gearing. This small difference is due, in part, at any rate, to the greater efficiency of direct coupling over the gear. Of course, gear transmission is not possible where speed is reduced or changed from, say, one to twelve or one to ten without some considerable loss of power. All this is saved in the direct connection, where the loss by transmission should not be more than a very few per cent. I think before the close of a year, at least before the close of next year, results will be obtained with direct coupling that will show it is possible to use a direct coupled motor even for such small work as street car work, that is quite as efficient, taking it all the way through, and taking the total efficiency of the system, as gearing.

Mr. SPRAGUE: I would like to make one remark in regard to lightning. We had the line struck by lightning several times, and we have had motors on cars burnt out, but I believe I may safely say now that we have got lightning pretty well harnessed. I believe now there is no difficulty whatsoever in absolutely and perfectly guarding a car or a central station, so that lightning simply cannot get to the machine. We have had the lightning come in and ground through the switch at the time the motor men were running the car. They paid not the slightest attention to it. They simply heard the click—that was the end of it. It will now be perfectly guarded against. It cannot get into our machines, and it cannot get into our stations; at least, if it does, it is only one time in 10,000, and then it goes to earth harmlessly.

THE ELECTRICAL AND ALLIED TRADES' SECTION OF THE LONDON CHAMBER OF COMMERCE.

At a meeting of the Committee held on Monday afternoon last it was first resolved that the presence of the reporters at that particular sitting be sanctioned. Sir DANIEL COOPER moved a resolution to the effect that in the case of firms and companies elected to the Committee they should be required to nominate the individual by whom they would be represented. The resolution was not carried; but it was arranged that the Secretary should request the companies concerned to state by whom they would be represented on the Committee. The report of the scrutineers of the election was then received, and letters declining the nomination were read from Sir James Anderson, Messrs. Alabaster and Gatehouse, and Mr. Quintin Hogg. The Committee proceeded to fill the vacancies so created and to decide the ties which had occurred in the ballotting, the result being that the Committee has been finally constituted as follows:—

COMMITTEE.

Telegraph Companies (5).

SIR J. PENDER.
MR. J. H. TRITTON.
THE MARQUIS OF TWEEDDALE.
MR. C. W. EARLE.
MR. R. K. GRAY.

Electrical Manufacturers and Contractors (13).

MR. R. E. CROMPTON.
MR. ALEX. SIEMENS.
MR. M. IMMISCH.
MR. E. GARCKE.
MESSRS. WOODHOUSE AND RAWSON (*Represented by* Mr. F. L. Rawson).
MESSRS. JOHNSON AND PHILLIPS (*Represented by* Mr. B. Pell).
MESSRS. LAING, WHARTON AND DOWN (*Represented by* Mr. C. J. Wharton).
MESSRS. CALLENDER AND SONS. (*Represented by* Mr. W. O. Callender).
MESSRS. DRAKE AND GORHAM (*Represented by* Mr. Drake).
SIR DANIEL COOPER.
MESSRS. W. T. GOOLDEN AND CO. (*Represented by* Mr. W. T. Goolden).
EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY (*Represented by* Major Flood-Page).
MESSRS. VERITY BROTHERS.

Telephone Companies (3).

MR. J. BRAND.
COL. R. R. JACKSON.
ORIENTAL TELEPHONE COMPANY (*Represented by* Mr. Grewing).

Electricity Supply Companies (6).

MAJOR-GENERAL WEBBER.
THE EARL OF CRAWFORD.
MR. J. E. H. GORDON.
MR. R. WALLACE.
MR. M. PARKER.
MR. R. S. ERSKINE.

Consulting Electrical Engineers (4).

MR. W. H. PREECE.
MR. G. KAPP.
MR. H. SHIRLEY PRICE.
MR. W. H. SNELL.

General (2).

SIR D. SALOMONS.
MR. HEAPHY.

Mr. Crompton was then unanimously elected as Chairman of the Section, and on a ballot being taken the Earl of Crawford and Major Flood-Page were elected vice-chairmen.

It was resolved that the meetings of the committee should be held on the first Monday in each month at 3 p.m. Some other business having been transacted, the committee adjourned.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

15,017. F. KENDALL. Towcester. An improved electrical indicator to show from which room or station a bell has been rung in domestic electric bell and telephone circuits. October 19, 1888.

15,030. J. GWYNNE and C. F. COOPER. London. Improvements in combined steam engines and dynamo-electric machines. October 19, 1888.

15,104. T. A. GARRETT and W. LUCAS. London Improvements in electric meters. October 20, 1888.

15,105. H. F. W. LEWIS, H. A. C. SAUNDERS, and A. C. BROWN. London. Improvements in fire-alarm telegraphs. October 20, 1888.

15,129. J. H. S. BRADLEY and J. H. WILSON. London. Maritime warfare, named or designated the "Automatic Electric Messenger," being an improvement in torpedoes, consisting of two horizontal thin tempered flexible steel fins to give greater stability and an increase of speed. October 20, 1888.

15,130. J. H. S. BRADLEY and J. H. WILSON. London. Maritime warfare, named or designated the "Automatic Electric Messenger," being an improvement in torpedoes, consisting of an automatic diving and floating rudder. October 20, 1888.

15,183. E. EDWARDS. London. Improvements in electrical telegraphs (E. Cassalette and D. Kunhardt, Germany). October 22, 1888.

15,206. A. B. BROWN. Glasgow. Improvements in apparatus for transmitting telegraphic indicating or other analogous signals or movements. October 23, 1888.

15,216. C. M. DORMAN and R. A. SMITH. Manchester. Improvements in the construction of switches for the making and breaking of circuits conveying electric currents. October 23, 1888.

15,237. M. W. W. MACKIE. London. An improved process for the manufacture of alkaline metals, such as aluminum, chromium, &c., by electrolysis and chemical reactions, and apparatus therefor. October 23, 1888.

15,249. S. Z. DE FERRANTI. London. Improvements in dynamo-electrical machines. October 23, 1888.

15,252. O. E. MADDEN and A. F. MADDEN. Improved machines for making battery-plates. October 23, 1888.

15,324. J. C. MARGETSON. London. Improvements in the means for establishing electrical communication in railway trains. October 24, 1888.

15,356. J. HULL. London. Improvements in or applicable to the coating and varnishing machines used in the manufacture of oil-cloth and in calenders and other machines used in analogous processes to prevent the same becoming electrically charged and thus dangerous to combustible materials by giving off sparks. October 25, 1888.

15,369. P. A. FICHET and A. NODON. Improvements in secondary batteries. October 25, 1888.

15,377. R. R. HUTCHINSON. London. Improvements in railways upon which the propulsion of vehicles is effected by means of both electricity and gravity, and apparatus in connection therewith. October 25, 1888.

15,388. A. SHIPPEY. London. Improvements in apparatus for regulating dynamo-electric machines (A. G. Westinghouse, United States). October 25, 1888.

15,395. P. CARDEW. London. Improvements in instruments for measuring and regulating electric currents and differences of potential, partly applicable to telegraphic purposes. October 25, 1888.

15,433. T. J. HANDFORD. London. Improvements in plates or electrodes for secondary batteries, and in the methods of making the same (L. Duncan, United States). October 26, 1888.

15,494. S. ORLOFF. London. Apparatus for operating dynamos by tidal and other like water-power. October 27, 1888.

15,508. L. Q. BRIN and A. BRIN. London Improved methods of producing aluminium and its alloys by means of electricity. October 29, 1888.

15,530. R. W. PAUL. London. Improvements in electrical indicators. October 29, 1888.

15,550. J. SACK. London. Improvements in apparatus for telephonic communication. October 29, 1888.

15,601. C. J. HARCOURT. London. Improvements in the manufacture of electric bell-push fittings. October 30, 1888.

15,612. J. C. LOVE. London. Improvements in insulators for electrical conductors. October 30, 1888.

15,626. P. SCHOOP. London. Improvements in electric batteries. October 30, 1888.

15,648. W. B. CLEVELAND. London. Improvements in electric switches. October 30, 1888.

15,713. Sir D. L. SALOMONS and H. FARADAY. London. An improved connector for electrical conducting wires. October 31, 1888.

15,741. P. V. MCMAHON. Improvements in dynamo electric machines. November 1, 1888.

15,755. A. J. JARMAN. London. Improvements in the construction of dry galvanic cells, and elements therefor. November 1, 1838.

15,766. C. BULMAN and A. B. TIFFEN. London. Ensuring the permanence of direction on the part of an electric current. November 1, 1888.

COMPLETE SPECIFICATIONS ACCEPTED.

NOTE.—*All persons interested in opposing the grant of a patent on any one of the undermentioned applications may, at any time within two months from the date in italics, give notice at the Patent Office in the prescribed form of such opposition.*

October 27, 1888.

15,878. V. POPP. London. Improved method for the distribution of motive power by compressed air or other fluid, and for the utilisation of such motive power for the generation of electricity and for other purposes and apparatus therefor. November 18, 1887.

16,296. A. F. ST. GEORGE and C. R. BONNE. London. Improvements in primary and secondary galvanic batteries. November 28, 1887.

16,603. A. J. BOULT. London. Improvements in electric lamps and in dynamos for the same, for velocipedes or the like (R. Weber, Germany). December 2, 1887.

17,155. T. A. EDISON. London. Improvements in incandescent electric lamps and cut-out devices therefor. December 13, 1887.

17,508. F. L. RAWSON and W. WHITE. London. Improvements in electrical switches. December 20, 1887.

17,528. C. ADER. London. A method and apparatus for phonic reception of telegraphed communications. December 20, 1887.

17,669. D J. SMITH and D. SINCLAIR. Glasgow. Improvements in telephonic apparatus. December 23, 1887.

17,762. L. SELLNER. London. Improvements in electric signalling apparatus. December 24, 1887.

17,812. C. ZIPERNOWSKY. London. Improvements in machines for the production of alternating electrical currents. December 27, 1887.

39. E. TYER. London. An improvement in voltaic batteries. January 2, 1888.

804. M. PULVERMANN. London. Improvements in electric clocks (C. Bohmeyer, Germany). January 18, 1888.

7,826. H. B. COX. London. Improvements in galvanic generators. May 29, 1888.

8,170. H. J. ALLISON. London. Improvements in and relating to automatically-regulated electro motors (The Baxter Electric Manufacturing and Motor Company (Incorporated), United States). June 5, 1888.

10,524. B. J. B. MILLS. London. Improvements in electric railways (The Bentley-Knight Electric Railway Company, United States). July 20, 1888.

11,092. G. M. CAPELL and J. S. RAWORTH. London. An improved combination of a steam engine having a vibratory and partly circular motion with a dynamo-electric machine. July 31, 1888.

13,008. J. W. OLDROYD. London. Improvements in electric incandescent lamps with interior reflectors. September 8, 1888.

13,125. W. H. CUTTING. London. Improvements in electric calls. September 11, 1888.

13,194. E. M. H. ANDREOLI. London. Improvements in ungumming and bleaching by electrolysis China grass, rhea, ramie, and other nettles. September 12, 1888.

13,325. H. H. LAKE. London. Improvements relating to electrical conductors and insulating conduits therefor (R. F. Silliman, United States). September 25, 1888.

November 3, 1888.

14,494. W. SPILKER. London. Improvements in electrolysing chlorides, bromides, and iodides, and in the utilisation of the products thereof. October 25, 1887.

16,455. H. THAME. London. Improvements in secondary or storage batteries. November 30, 1887.

16,537. F. WYNNE. London. Improvements in or pertaining to means or apparatus employed in the application of electricity to propel vehicles, applicable also for other purposes. December 1, 1887.

16,962. F. RUDALL. London. Improvements in stays for telegraph-poles, masts, and the like. December 9, 1887.

17,585. N. BENARDOS. London. Improvements in electric regulators. December 21, 1887.

17,846. G. L. ANDERS, J. S. SAWREY, and H. COLLET. London. Improvements in telephonic apparatus. December 28, 1887.

17,926. W. E. HAYNE. London. Safety fuses for electrical circuits. December 30, 1887.

115. S. W. BAYNES. London. Improvement in the insulation of electric appliances. January 4, 1888.

569. W. HEDICK. Breda, Holland. Improved method and apparatus for recording and reproducing sounds and electric currents. January 13, 1888.

11,817. J. C. HOBBS. United States. Improvements in electric furnaces. August 16, 1888.

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13,584. E. MEYER. Glasgow. Improvements in electric tell-tales. September 20, 1888.
13,984. B. J. B. MILLS. London. Improvements in electrical accumulators (J. Barbier, France). September 28, 1888.
14,129. H. H. LAKE. London. Improvements in and relating to dynamo-electric machines (E Thompson, United States). October 2, 1888.

PATENTS SEALED.

October 26, 1888.

13,720. A. DE KHOTINSKY. Rotterdam. Apparatus for effecting electrical measurements and contacts. October 10, 1887.
14,209. W. H. RUSDEN. Cardiff. Improvements in electrical apparatus for prevention of corrosion and incrustation in steam boilers. October 19, 1887.
14,247. W. PARKINSON. Accrington. Improvements in dynamometers (J. Wallace, India). October 20, 1887.
15,455. W. S. ROGERS. Chiswick. Apparatus for connecting a number of separate electrical conductors to one main conductor. November 11, 1887.
713. T. COAD. Forest Gate. Improvements in voltaic or galvanic batteries. January 17, 1888.
7,619 G. J. WEIR. Glasgow. Primary electric battery. May 24, 1888

November 2, 1888.

12,414. F. C. PHILLIPS and H. E. HARRISON. London. Improvements in electric arc lamps. September 13, 1887.
13,853. G. A. CALVERT. Cork. Improvements in and connected with telegraphic apparatus for transmitting orders or other communications. October 13, 1887.
14,954. W. TERRILL. Swansea. Improvements in apparatus to be used in the deposition or treatment of metals by the electrolytic process. November 2, 1887.
8,637. A. L. PARCELLE. United States. Improvements in electric clocks. June 12, 1888.
10,631. E. KASELOWSKY. Berlin, Germany. Improvements in electrical night-signalling apparatus. July 23, 1888.

SPECIFICATIONS PUBLISHED DURING THE WEEK.

13,326, 1887. DOUGLAS, J., and ABBOTT, H. Producing and administering electric shocks and currents. (Price 8d.)
15,063, 1887. SKRIVANOW, P. Galvanic batteries. (Price 4d.)
16,623, 1887. GOOLDEN, W. T., and ATKINSON, L. B Dynamo electric generators, &c. (Price 8d.)
17,089, 1887. IMMISCH, M. Electro-motors and dynamo machines. (Price 8d.)
7,463, 1888. KOTYRA, M. Commutator for magneto, &c., generators. (Price 6d.)
12,395, 1888. BOULT, A. J. (Pratt). Electro-therapeutic belts. (Price 8d.)
12,706, 1888. THOMPSON, W. P. (Gibson). Storage battery plates. (Price 6d.)
12,761, 1888. WATERHOUSE, A. G. Dynamo-electric machines. (Price 8d.)
14,632, 1887. TIMMIS, J. A. Electrically lighting railway trains. (Price 8d.)
15,161, 1887. EVERITT, P. Coin freed electrical current-producing apparatus. (Price 8d.)
16,324, 1887. SCHMIDT, F. T. Electro-mechanical striking gongs. (Price 8d.)
16,870, 1887. TATHAM, R. Electro-dynamic generators, &c. (Price 8d.)
17,031, 1887. LAHMEYER, W. Regulating electric currents, &c. (Price 8d.)
17,409, 1887. MCEVOY, C. A. Electrical primers. (Price 6d.)
729, 1888. URQUHARDT, D. Electric batteries. (Price 6d.)
12,384, 1888. RUTZLER, E., and BLAKE, G. W. Thermostats. (Price 8d.)
12,396, 1888. THOMPSON, W. P. (Edgecombe). Electric motors for self-winding clocks. (Price 8d.)
12,437, 1888. CONNER, W. A. and M. J. W. Electrical conductors. (Price 8d.)
13,128, 1888. IRWIN, J. Electric railway signalling systems. (Price 8d.)
13,193, 1888. ANDREOLI, E. M. H. Bleaching paper pulp by electrolysis. (Price 6d.) Second Edition.
3,576, 1882. HOPKINSON, J. Distributing, &c., electricity. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

West India and Panama Telegraph Company (Limited).

Report of the Directors for the half year ended 30th June, 1888, to be submitted to the twenty-third ordinary general meeting to be held at Winchester House, 50, Old Broad-street, London, E.C., on Wednesday, the 14th inst., at 12 o'clock :—

1. The amount to credit of revenue is £49,965. 2s. 0d., and the expenses have been £27,578. 5s. 3d., leaving a balance of £22,386. 16s. 9d., which, with the balance of £1,606 2s. 9d. brought forward from last account, makes a total of £23,992. 19s. 6d. Of this sum the Directors have placed £2,000 to reserve, leaving an available balance of £21,992. 19s. 6d., with which it is proposed to deal as follows :—Payment of 12s. per share on account of arrears of dividend on the First Preference shares £20.737 16s 0d. ; balance to current half year's account £1,255. 3s. 6d. ; total, £21,992. 19s. 6d.

2. The traffic receipts for the six months show an increase of £2,010. 7s. 9d., as compared with the corresponding period.

3. The expenses for repairs to cables are £2,241 in excess of those for the corresponding half-year, owing to an increased number of repairs having been executed, and to the laying in of a greater length of new cable, for the purpose of strengthening the communications.

4. The Company's ss. "Grappler" arrived in the Thames in May last, and, after being docked and repaired, returned to St. Thomas's with 258 knots of new cable for stock.

Australasian Electric Light, Power and Storage Company (Limited).

Report of the Directors to be submitted to the shareholders at the sixth ordinary meeting of the Company, to be held at the offices of the Company, 41, Coleman-street, E.C., on Monday, the 12th inst., at 3 p.m.

Shareholders will note that as these accounts, being up to the end of last year, cover only two months under the new system of expenses, they do not show the advantages reaped from that arrangement, which was adopted at the general meeting held in October, 1887.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
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PHOSPHOR BRONZE.
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BEARINGS, BUSHES,
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Since the date of last report, the efforts of the Board have been largely directed to obtaining and executing the contract for the lighting of the Melbourne Centennial Exhibition, and in conjunction therewith a sale of the plant so to be used. In both of these objects they have been entirely successful.

Having a considerable quantity of suitable stock on hand on the spot, and the advantage afforded by the factory of the Melbourne affiliated company, the contract was obtained by this company on terms which will leave, according to the general manager's report, a very satisfactory profit to both companies. The original and main contract is in the form of a sale, with further arrangements for the erection and working of the plant, amounting in all to about £34,640; but since this first contract further arrangements have been made which add considerably to the magnitude of the installation, and this latter contract is of the nature of hire with option of purchase. The following extract from the official report of the commissioners shows the satisfactory manner in which the contract has been carried out by the company. They say:—"Referring to the lighting of the building by means of the electric light, the Executive has great pleasure in stating that, after a month's trial of what is stated to be the largest single installation in the history of electric lighting ever attempted by a single company, it has proved a marked success."

It is needless to add that every advantage is being taken of this exceptional position to profit by it as a means of extending the ordinary selling business of the Company, and the General Manager anticipates a very marked increase in the sales.

In the report issued in February, 1887, allusion was made to the satisfactory extension that was being given to the operations of the Melbourne Company's lighting station. Unfortunately, the local directors of that company failed to obtain sufficient support financially to keep pace with these developments. In these circumstances an offer was made of very substantial assistance from this Company. At this juncture, however, a foreign firm of electrical engineers offered to supply plant on very easy terms of payment, and, acting under this inducement, the local company adopted for their extension the foreign system. From these circumstances many misunderstandings and difficulties have arisen, which have seriously crippled the Melbourne Company, whose local shareholders have now insisted upon a reconstruction, the precise details of which have not yet been received here.

At the same time preliminary arrangements have been made in Melbourne for raising a considerable capital by local capitalists for the development of electric lighting on a large scale. There have been certain negotiations with this group, but at the present moment the directors are not in a position to make any statement with regard to them. In the meantime, it is very evident that a great development of electricity in all its branches is just commencing in the Colonies, and that very remunerative work is to be had for a company strong enough to undertake it.

An arrangement has been made with Messrs Gibbs, Bright and Co., Melbourne, who have consented to act as consulting agents to this Company, and it is believed that this will prove of great benefit in future transactions.

Major Flood-Page has unfortunately been obliged, by stress of his other occupations, to retire from the Board, but continues to assist the Company with his advice when consulted. The Directors retiring by rotation at this meeting are Messrs. Van Tromp and Sanderson, who, being eligible, offer themselves for re-election.

The auditors, Messrs. Deloitte, Dever and Co., also retire, and are eligible for re-election.

NEW COMPANIES REGISTERED.

CROMPTON AND CO. (LIMITED).—This company has been formed to acquire the business, freehold premises, plant, stock, and goodwill of R. E. Crompton and Co., electric light engineers, Chelmsford and London. The capital is £140,000, in shares of £5 each, consisting of 20,000 7 per cent. preference shares and 8,000 ordinary shares, and the present issue is of the preference shares, about half of which, it is stated, have already been privately subscribed by the directors and their friends. Messrs. Crompton and Co. have, from the beginning of the electric light movement, taken a prominent part in the manufacture and installation of lighting plant, and have established a reputation for satisfactory work. It is stated that the business has grown considerably during the last few years, and that the orders now on hand, together with those in negotiation, are of such magnitude as to make it a matter of necessity that additional capital should be provided. It is in order to enable this capital to be subscribed under the protection of limited liability that the undertaking has been converted into a public company. The books of the firm have been examined by Messrs. Duncan Bryce and Co., chartered accountants, who certify that the profit for the five and three-quarter years ended March 31, 1888, has amounted to £40,029, being an average of £6,969 per annum, and that the balance-sheet for the last nine months of that period shows a net profit of £8,912. Since this certificate was prepared it has been ascertained that the amounts therein set aside to provide for bad and doubtful debts and completion of work in hand were not sufficient. The consequence is to reduce the profit for the last nine months; but the effect of this on the average profits for the six years is, it is stated, immaterial.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 2nd, 1888, amounted to £4,949.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of October was 4,210, estimated to produce £3,300, against 3,417 messages, producing £3,024, in the corresponding month of last year. The traffic receipts for the month of July, estimated at £3,100, realised £3,086.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of October, 1888, amount to £2,210, against £2,276 in the corresponding period of last year, a decrease of £66.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October, 1888, amounted to £55,742, and to £53,089 in the corresponding period of 1887, an increase of £2,653.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October, 1888, amounted to £38,660, against £40,018 in the corresponding period of 1887, a decrease of £1,358.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—In our advertisement columns will be found a notice that on the 16th inst. 260 First Mortgage Debentures will be drawn for payment on Jan. 1, 1889.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for October amounted to £23,600, and for the period from 1st January to 31st October to £226,200. For the corresponding months of 1886 and 1887 they amounted to £217,800 and £220,880 respectively.

MEXICAN TELEGRAPH CABLE COMPANY.—This company has just declared a quarterly dividend of 2½ per cent., being the usual rate.

SOUTH OF ENGLAND TELEPHONE COMPANY (LIMITED).—The directors of this company at their meeting on Thursday last, declared a dividend of 6 per cent. per annum on the preference shares of the company for the half-year ended 31st October.

SUBMARINE CABLES TRUST.—The balance of 10s. on the coupons of the Submarine Cables Trust, due last April, will, it is announced, be paid on the 15th inst. Further particulars will be found in our advertisement columns.

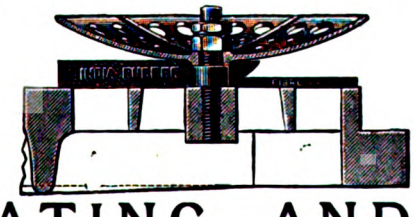
WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended October 31st, 1888, amounted to £6,600.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 2nd, 1888, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £4,110.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half month ended October 31th, 1888, were £2,715, as compared with £2,803 in the corresponding period of 1887, a decrease of £33.

NEW VALVE

No Rubber, Percha, or Leather.



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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Nov. 7, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Nov. 7, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American ....xd	47 48	2 17 3	Jan., Apr., July, Oct.	47⅜	47⅛
2,614,820	Stock	15/0	Do. Preferred ....xd	78½ 79½	3 9 2	,, ,,	79⅜	78⅜
2,614,820	Stock	nil.	Do. Deferred	15½ 16	...	February	16¼	15⅝
130,000	£10	5/0	Brazilian Submarine	13¼ 13½	5 3 8	Mar., June, Oct., Dec.	13 9/16	13⅜
16,000	10	9/0	Cuba Submarine ....xd	13¾ 14¼	5 19 9	February and August	...	...
6,000	10	10/0	Do. Preference ....xd	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3¾ 4¼	3 15 4	March & September	4⅛	...
6,000	5	10/0	Do. Preference	9 10	5 0 0	April and October ...	...	...
60,710	20	2/0	Direct United States ....xd	9¾ 10	4 0 0	Jan., Apr., July, Oct.	10	...
380,000	10	4/6	Eastern	12⅝ 12⅝	4 15 1	,, ,,	12½	12⅜
70,000	10	3/0	Do. 6 per Cent. Preference	14¾ 15¼	3 19 0	,, ,,	15¼	14⅞
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	3 18 0	February & August	...	...
250,000	10	2/6	Eastern Extension	13 13¼	4 18 1	Jan., Apr., July, Oct.	13¼	13 1/16
22,050	10	8/3	German Union Telegraph and Trust	9 9½	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅞ 7⅛	4 18 3	Jan., Apr., July, Oct.	7 1/16	6⅞
178,992	10	3/0	Do. 6 per Cent. Preference	14⅝ 14⅝	4 2 1	,, ,,	14 9/16	14⅝
150,000	10	5/0	Great Northern	14 14½	5 3 5	Jan., July, and April	14⅝	...
17,000	25	12/6	Indo-European....xd	38 40	6 5 0	April and October	39½	...
33,348	10	3/0	London Platino Brazilian	7 7½	...	May and November	...	...
9,000	8	4/0	Reuter's	7¼ 7⅜	5 3 2	April and October ...	7¼	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
30,000	10	6/0	West Coast of America	8½ 9	5 11 1	January and July ...	8¾	8
150,000	Stock	8%	Do. Debentures	121 125	6 8 0	June and December	...	...
88,321	10	nil.	West India and Panama	2 2¼	...	...	2 5/16	2
34,563	10	12/0	Do. 1st Preference	12¼ 12⅜	8 12 6	April and October ...	...	...
4,699	10	*	Do. Six per Cent. 2nd Preference.... ...	11⅛ 12⅜	...	...	12⅜	12
45,181	15	6/0	Western Brazilian .... ..xd	13⅜ 14¼	5 7 6	March & September	14⅛	13¾
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage .....xd	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	9/16 11/16	5 10 0	Yearly	...	...
220,000	£1	2½%'87	Oriental (11s. paid).....	1/16 1/16	3 9 0	...	...	...
80,000	5	10/0	United	13¼ 13⅜	5 9 1	June and December	13⅜	13⅛
275,000	5	4/6	United River Plate.....	5½ 5¾	...	July and January ...	5⅝	5½
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4⅛ 4⅜	...	...	4⅝	4½
23,692	5	nil.	Do. (fully paid)	5¼ 5⅜	...	February & August	5⅝	5⅛
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2 1/16	2⅛
312,000	¼	5% '86	Maxim-Weston.....	1/16 3/16	...	February	1/16	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	38½ 39½	6 1 3	March and July.....	39½	39
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works...	16½ 17½	5 14 3	February & August	17½	17

* No dividend since May, 1880.

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THE NORTH BRITISH RUBBER CO., LIMITED.
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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 548.—Vol. XXII. FRIDAY, NOVEMBER 16, 1888. Price 4d.

NOTES.

Our New York correspondent telegraphs under date November 13th as follows:—"United States Supreme Court reverses decision of lower Court, Massachusetts, and holds that Government can bring suit there to invalidate Bell. Decision upsets every point raised in Bell demurrer, but involves no direct electrical issue."

It hardly need be said that this is a decision of the highest importance. Those who have followed the course of events in connection with the endless litigation on the Bell patents will remember that in the Circuit Court at Boston some months ago a decision was given in the action brought by the Attorney-General on behalf of the United States Government, in which it was alleged that the Bell patents were obtained by fraud, and that the specification contained particulars taken from the patent of Elisha Gray, whose application was at the same time in the possession of the Patent Office, and leave was therefore applied for to cancel the patents. The Boston Court held, however, that in the absence of any specific statute they had no power to grant leave to cancel a patent. The Court further expressed an opinion that the allegations raised against the validity of the patent would, if sustained, form a ground of defence in any suit brought by the Bell Company for infringement, and that this fact debarred the Attorney-General from proceeding. This decision was immediately appealed against, and we now learn from our correspondent's telegram that the Supreme Court has wholly upset the judgment of the Court below. Thus it would seem that the whole question of the priority of invention of the telephone is again thrown open. Whatever the final result may be it is a matter of great regret that allegations of the character in question should find any place in the history of one of the most beautiful and useful adaptations of electrical science.

A financial paper "understands that the promoters of the scheme for laying a cable across the Pacific from Vancouver to Australia have arranged for a public meeting to be held at Cannon street Hotel on the 21st of this month, in order to bring their undertaking more prominently under public notice. They propose to get up a deputation to wait upon Lord Salisbury to induce him to take an interest in the undertaking, and to order the expedition of the survey of the bottom of the Pacific which the Admiralty have been engaged upon for some time.'

It is interesting to contrast this appeal to Government with the action of the Eastern and South African Company, which is about to lay lines on the West Coast of Africa. On her way to the Cape of Good Hope the cable ship "Amber" took 380 soundings between Bonny and Cape Town, over a zig-zag course of 3,377 miles. The total distance in a direct line would be 1,624 miles, which, if divided by the number of soundings obtained, would represent one sounding to every 4¼ miles. The aggregate number of fathoms of sounding wire run out was 212,065, and the wire lost 2,526, or about one per cent. On her way northward the same vessel will take a second line of over 100 soundings, extending over 1,100 miles.

Mr. Harold P. Brown (in a letter which will be found in our correspondence columns) "trusts that we will modify our opinion on the dog-killing experiments." In our issue of October 5 (page 691) we expressed the opinion that Mr. Brown's experiments "had conclusively proved that an alternating current is fatal *to a dog* at a very much lower potential than a continuous current." We really do not see our way at present to "modify" this opinion, nor do we quite understand in what direction Mr. Brown wishes a modification to be made. If, however, Mr. Brown is asking us to admit that he has demonstrated that the use of alternate currents of 200 volts and upwards ought to be interdicted, then we must decline to allow that he has said or done anything which leads to such a conclusion. Against Mr. Brown's experiments on dogs, and his vivid picture of the terrible condition of overhead wiring in the States, we set the fact that 35,000 lamps in London are already wired in overhead circuits carrying 2,400 volts, and that not a single accident has hitherto resulted. It is true that nearly two years since, a lad, who had no business to touch the wire at all, tried to cut the line with a pair of pliers, and fell through a skylight and was killed, but an occurrence of this kind cannot fairly be charged against the system itself. Moreover, as we have before stated, several *employés* of the company in question have received shocks of the full potential of 2,400 volts without serious result. What does our correspondent make of these facts? We may add, in conclusion, that Mr. Brown undoubtedly deserves credit for calling attention to the dangerous condition of the New York high-tension circuits, and what he has really done is to enforce the lesson that the design and construction of such lines must be brought to the highest possible state of perfection.

The simple fact that the filament of an incandescent lamp continues to glow a brief interval after the cessation of the

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current, has been seized upon by not a few ill-instructed enthusiasts who have proposed to increase the available output of current generators by distributing the current momentarily between a number of separate circuits. This is evidently one of those ideas from which the Patent Office is entitled to expect a permanent source of revenue. A patent has recently been granted to T. A. Edison, in which identically the same *modus operandi* is employed, with the view, however, not of increasing the available energy, but of distributing what may be called the virtual potential between several different circuits. The object is, in fact, to secure a system of high-tension distribution with continuous currents. Mr. Edison appears to have discovered that an incandescent lamp of, say, 100 volts, when subjected, at intervals of a second, to an E.M.F. of 500 volts for periods of one-fifth of a second, will give the same light as it would under a continuous E.M.F. of 100 volts. This was perhaps to be expected; but it would be interesting to know whether the life of the lamp does not suffer. Mr. Edison proposes to employ this method for the distribution of high-tension electricity, and its utilisation in lamps or motors designed for currents of lower voltage. The high-tension current is to be taken either to local centres or to the house of the consumer, and is there to be placed on a distributing commutator, driven by an electric motor, by which it will be placed on a number of separate circuits each for the required interval of time. So far as our present information extends, we must confess that we entirely fail to see the advantage of the plan. There is no real transformation of potential, and even if the difficulty of sparking at the commutator be overcome, the necessity for employing an electric motor in every circuit is a most serious drawback; in fact, if it were not associated with the name of Edison we should not have thought the proposal worth attending to. We wonder, by-the-bye, what has become of Edison's motor-generator central station at Llewellyn Park.

It is understood that the Metropolitan Electric Supply Company have given the Westinghouse Company a contract for the equipment of a central station adapted for 3,000 lamps in Sardinia-street, Lincoln's-inn-fields. Some regret has been expressed that the company should have adopted plant of foreign manufacture, but we believe it will be found that additional orders will be placed in English hands, and it is also to be remembered that the Westinghouse Company own a considerable number of patents taken out by English inventors. At the same time it is easy to understand that this renewed American invasion is not exactly welcomed in many quarters.

The Kensington Court (Draft) License, of which we published the full text last week, raises an issue of considerable importance, and upon which the terms of the license appear to be inconsistent if not contradictory. The question is as to the degree of responsibility attaching to the undertaker in respect of the lamps, fittings and wiring of the consumers' premises. Clause 13, under the head of Regulations as to Supply, says:—

"The undertakers shall not be in any way responsible for any defects in the construction of any electric lines or fittings within such premises . . . . where such electric lines or fittings have not been supplied by them, nor for any neglect in the maintenance of any such electric lines or fittings where they do not belong to the undertakers or are not under their control."

And yet under "Regulations as to Safety," Clause 1, we read:—

"The electricity shall be delivered to the poles on the consumers' premises in some manner free from risk of causing fire on the premises in question, whether such fire should or might be . . . . partly due to any defective action of the lamps, motors, storage cells, conducting wires, or other fittings connected with the poles for the purpose of using the supply of electricity."

It is clear that one or other of these clauses must be remodelled; and we think there can be no question that the *intention* of the Board of Trade, whilst providing for all reasonable safeguards, is to free the undertaker from responsibility for the consumers' fittings. The whole question is to be discussed at a meeting of the Committee of the Electrical Trades Section, to be held this (Friday) afternoon, when it is probable that an attempt will be made to frame a model set of regulations on the lines laid down by the Board of Trade, but which, with suitable modifications, might be adapted for central lighting stations on any system.

Lord Armstrong's rejoinder in this month's *Nineteenth Century* on what he calls "The Cry for Useless Knowledge" has certainly the merit of putting in clear terms the irreconcilable divergence of views which are entertained on the subject of technical instruction. Sir Lyon Playfair, the spokesman of the Technical Association, is an advocate for including within the scope of technical education the teaching of specific trades and industries. "I, on the contrary," says Lord Armstrong, "hold that workshops and factories, or other places where actual business is carried on, are the proper schools for the learning of such trades and industries." It is well to have no illusions on a matter of this importance; and from actual experiment at his own works and with his own workpeople, Lord Armstrong draws the conclusion that, neither from economic considerations nor from consideration of advantage to the workmen *as a body*, is "a knowledge of the sciences and arts which lie at the basis of all industries"—the ideal of Sir L. Playfair—either profitable or attainable.

Sir L. Playfair's contention that the workmen "desired to dignify and fructify their labour by understanding it" is easily demolished by proofs that they (again *as a body*) have no such aspirations. For our part we believe Sir Lyon would admit these proofs if pressed a little harder, and would then shift his ground to one which savours more of polities than of economics. What he really desires is that the workman shall be made to dignify, and so forth, whether he likes it or no. A similar desire, with its inevitable complement, has been caricatured in America. "Every citizen shall be free to do what he darned pleases; and if he doesn't we'll make him." There is something to be said, no doubt, for compulsory technical instruction, as for compulsory education in general. But Lord Armstrong does well to remind us that national decadence cannot be averted by academic remedies of this description.

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THE township of Allendale is apparently prepared to pin its faith to Mr. R. P. MILBURN and his "new patent electric light."

"The interesting proceedings" (says the *Hexham Courant*) "were witnessed by a large number of people, and general satisfaction was expressed with the result of the trial. Lights of 10 and 27 candle-power were produced, the effect of which was in every respect highly satisfactory, whilst general surprise was evinced at the simplicity of the apparatus for the generating and storing of the electricity. Subsequently, a meeting of the committee was held in the Church Sunday School Room, Mr. M. Stephenson presiding. Mr. Milburn gave particulars regarding his electric light and the method of applying it to the town. As to the cost of maintenance, he stated that it would cost *about ½d. an hour for twelve lights* such as they would require. . . . The process would be this: They would make a battery to last thirty hours; the electricity would be generated from the primary battery, passed into the secondary or accumulators, and from thence to the lamps. . . . As to the first cost, he could not just then say anything definite, but as soon as he had ascertained what the pottery manufacturers would make these special batteries for—made of earthenware—he would draw up an estimate and forward it to them. . . . Assuming that it took six cells to drive 12 lamps, anyone desiring to have the light brought into their private dwellings could have it by adding another cell. To obtain the light by water or motive power would cost a great deal more than by his system, the dynamo alone probably costing £150. His system of a chemical battery was on the same principle as the paraffin lamps, but instead of paraffin oil they poured chemicals in, and having connected the wires they obtain the lights. Mr. Milburn further remarked that there were only two chemical batteries at the present time—one a German patent, and the other his own, so that really the thing was quite in its infancy. Mr. Walton: If we go in for this light I suppose we will be the first town in the kingdom that will have done so.—Mr. Milburn: Yes."

That the "chemical battery on the principle of the paraffin lamp is *quite* in its infancy," and that Allendale will really be the very first place in which an electric light of 10 candle-power has been maintained at a cost of one twenty-fourth of a penny per lamp-hour, are propositions of which Mr. MILBURN may be left in undisputed ownership; and we should advise Allendale not to deprive him of them at any price.

The Trinidad-Demerara Cable.—We learn that the cable between Trinidad and Demerara is now repaired.

Wath-on-Dearne.—Messrs. Charles Stanley and Son, who have recently erected extensive additions to their South Yorkshire Oil and Soap Works, have had the latter department lighted throughout with electric light.

A Corner in Zinc.—The *Cote Libre* mentions a Belgian-German combination to take charge of zinc on the lines of the Copper Syndicate. The principal producers of the Rhine district will take part in the movement.

The Cox-Walker-Swinton Magneto Electric Bells.—The Royal Cornwall Polytechnic Society have awarded the Equitable Telephone Association a prize medal for the exhibit of the above at the recent Falmouth Exhibition.

"The Elementary Principles of Electric Lighting."—A new and revised edition is now in the press of "The Elementary Principles of Electric Lighting," by A. A. Campbell Swinton, and will shortly be published by Messrs. Crosby Lockwood and Co. The first edition is out of print.

Bournemouth.—At a meeting of the Improvement Commissioners, last week, a letter was read from Mr. St. Aubin Angrove, of London, asking them to sanction an application to the Local Government Board for permission to lay down electric tramways from the eastern district of Bournemouth to the Arcade, and from Poole to the top of Commercial-road, West Bournemouth. The commissioners thought tramways connecting the outlying districts with the town desirable, but opposed their being laid down in the town proper.

Eastern Telegraph Company (Limited).—This company have called a meeting of shareholders to authorise the issue of 20,000 new shares of £10 each for the purpose of enabling the company to subscribe and pay for a like number of shares of the Eastern and South African Telegraph Company (Limited). The latter company is about to lay a line of cables along the southern part of the West Coast of Africa, from the Cape to Loanda, where it will join the existing lines, forming an important alternative route to the Cape; and while adding greatly to the security of the service will, in the opinion of the directors, yield satisfactory results to the Eastern Company.

An International Telephonic System.—At the last International Telegraph Congress telephonic questions were practically ignored. We learn, however, that at the forthcoming meeting of the Congress at Paris, there is to be a special telephone section. One of the main objects of this section will be to formulate a large scheme of international telephony, whose ramifications will embrace Paris, Berlin, Vienna, Brussels, Rome, and Amsterdam, and, according to our authority, London also. Of course, the first step towards the practical realisation of the scheme must be the adoption of a uniform telephone tariff and system of regulations.

The Gulcher Company.—We are informed that the Gülcher Company have secured the contract for lighting Messrs. W. and J. Players' new rolling mill, Spring Hill, Birmingham. Six 2,000 candle-power Gülcher arc lamps will be used for lighting the mill, and the dynamo and engine are being put in large enough for 10 lamps, in case it is necessary to extend the mill, in which case the balance of power will be used for running incandescent lamps. The Gülcher Company have also just completed the lighting of the Sunderland Co-operative Stores with three Gülcher arc lamps and incandescent lamps. A 3,000 candle-power lamp is placed on a bracket in front of the building for lighting the street.

Kensington.—The question of the lighting of the parish of Kensington by electricity came up at the Kensington Vestry meeting yesterday.—Mr. Lindsay objected to mapping out the parish, as was proposed, to four companies, and said the committee pretended not to want to grant a monopoly, but that would be virtually created by the adoption of their proposal. He therefore proposed that the vestry should give authority to the whole seven companies that had applied for permission to supply light, without allotting any particular part of the area. Mr. Lindsay's proposal was carried by 38 to 19.—Messrs. Jordan (chairman), Duffield, and Wilson resigned their position on the committee in consequence of this decision.—Ultimately the vestry reconsidered their decision, and postponed the matter for a fortnight.

Bristol.—At a recent meeting of the Bristol Sanitary Authority the chairman stated that a committee had been appointed by the Council to consider the question of electric light. They had already had an offer from a gentleman who had succeeded in placing the electric light in Bath and Taunton. They gave him the cost of gas throughout the main streets which it was suggested should be lighted in Bristol, and pointed out to him that the committee would probably agree to adopt the electric light if it could be done at the same cost as the gas. He (the chairman) did not think that at present it could be

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done at the same cost; but the system had been adopted in other towns, and he thought the time was arriving when it should receive their consideration. What he wished to point out was that the matter had not been lost sight of.

The London Chamber of Commerce.—Electrical and Allied Trades Section.—The following circular has been issued to the members of the section:—"Dear Sir: The committee of the above section, which has just elected Mr. R. E. Crompton for its chairman, and the Earl of Crawford and Major Flood Page for its vice-chairmen, are desirous of proceeding to the discussion of questions primarily affecting the trade. With this object they wish to take the opinion of the members of the section at large as to which are, in their opinion, the topics most pressing for immediate consideration. I shall be glad, therefore, if you will kindly send me, at your early convenience, or in any case not later than the 18th instant, a list of such questions as you would suggest should be brought under the notice of the committee, inscribing them in the order of the importance which you may attach to them.—Yours faithfully, KENRIC B. MURRAY, Secretary."

Supposed Death from Electricity.—"A man, aged forty-six, is supposed," says the *Lancet*, "to have met his death on Saturday last from an electric shock when following his employment at the Consett Iron Company's works, county Durham. It appears that the supply of light was interfered with owing to the wind fraying the gutta-percha covering of the wires, and to get at the defect he had to cross along a slippery plank leading from the top of the boilers. The general impression is that by not wearing the gloves provided for such occasions he had received a shock from the uncovered wires; at all events, he was found on the ground with a wound on the back of his head. Life was not then extinct. He was removed to the County Infirmary, and died in about two hours. Strange to say, in a case like this, where medical evidence might have been useful, if not essential, to determine the real cause of death, the coroner did not call any, notwithstanding the remark of one of the jury that 'there certainly ought to have been a doctor here.'"

Improvements in Secondary Battery Plates.—A correspondent writes us as follows:—"In the *Electrical World* of October 27 a new secondary battery of M. Faure's is described. This invention seems likely to revolutionise secondary battery construction, since M. Faure substitutes the work of the individual molecule for that of the concrete plate. There is a striking resemblance between M. Faure's latest device and that of M. Bandsept (see *The Electrician*, 4th May, 1888), who completely solved the question from the point of view of molecular work. M. Bandsept, it will be remembered, made his electrodes of finely divided material, which was compressed into plates while played upon by a fine spray of some liquid suitable for the end in view. The chemical reaction is consequently more thorough and more powerful. Looking at the question from this aspect, there can be no doubt as to the great importance of work like that of M. Faure. In virtue of mechanical laws, this scientific solution of the problem ought to give tangible and good results."

Fire at Messrs. Willans and Robinson's.—A destructive fire occurred at the Thames Ditton premises of Messrs. Willans and Robinson early on yesterday morning, resulting in the complete destruction of the machine shops, the smithy, and the foundry. We understand that the firm had in hand at the time of the fire upwards of one hundred engines for electric lighting purposes; but that the system of construction pursued at these workshops—the parts of the engines being independently constructed to guage and template—will enable the firm to replace their stores from outside sources, and so complete their contracts without serious delay. The erecting shop in which there were many engines in course of erection were saved. Only a few dynamos were destroyed, as many of the engines on the premises were waiting dynamos which had not yet arrived. All drawings, books, and papers were rescued, and a large stock of castings remained uninjured. Steps have already been taken to replace the machinery, and the firm have received many prompt and kind offers of assistance from other firms with whom they do business.

Barnet.—At a recent meeting of the Barnet Local Board the Lighting Committee reported that the electric lighting contractor (Mr. Joel) had been in communication with them on the subject of the complaints made in regard to the lighting, and had stated that he had every reason to believe that everything would be in proper working order by the 20th inst. The committee had inspected a 32 candle-power lamp; and the contractor had undertaken that all the lamps should be worked to a similar standard, with the addition of reflectors and improved appliances. The report having been received, Mr. James said that, taking into account the time that had elapsed since the first attempt to light the town by electricity, he thought the Board should take some decisive action. They had had a good many promises, but none of them had been carried out. He proposed that notice should be given to the contractor to terminate his contract, expressing the opinion that by so acting the Board could not be accused of undue haste or want of consideration. Mr. Samuels pleaded for the contractor, saying that he considered the Board would do a very unwise thing if they gave the notice. He moved, as an amendment, that the recommendation of the Lighting Committee as to the notice be not acted upon; and this was adopted.

The Lighting of Mr. Alfred C. de Rothschild's Town House. Messrs. E. T. Mackrill and Co., of Aylesbury, have just completed a fine installation at Mr. Alfred C. de Rothschild's house in Seamore-place. The engines and dynamos are situated in the stables some 250 yards away from the house, the current being taken to the lights by means of 37/12 insulated cables, laid under the roadway in 5-inch iron pipes. The generating plant consists of two 9 horse-power (nominal) Otto gas engines, which drive direct, through 6-inch belting, two shunt-wound dynamos having each an output of 145 volts and 65 amperes. These machines supply current to 165 E.P.S. accumulators, arranged in three parallels of 55 each; the cells are of the 31 L 1888 pattern, with a capacity of 600 ampere-hours. The station is provided with the usual charging, discharging, and distributing switches, as well as ammeters, voltmeters, and resistance coils. In addition to supplying current for the lights, the cells are used to drive a small E.P.S. motor actuating a Blackman air propeller, and also to start the gas engines, the dynamos being momentarily converted into motors. The lights, some 300 in number, are mostly of 20 candle-power. Every group is arranged throughout in two sections, and the artistic possibilities of the electric light are everywhere made the most of. Cockburn's fuses, it may be added, are used wherever necessary. This is, we believe, the first private undertaking which has been allowed to run cables under the roads.

Electric Lighting Activity.—As an instance of the activity now prevalent in electric lighting circles, we give the following list of installations upon which Messrs. B. Verity and Sons are either at work or have quite recently completed:—An installation of 800 lights for the Earl of Rosebery's house at Mentmore; an installation on board the steam yacht "Eros," for Baron Arthur de Rothschild, of Paris; an installation of 500 lights, similar to the Earl of Rosebery's, for Sir John Dixon

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Poynder; an installation of 3,000 lights, Willans' engines and Siemens' dynamos, is being commenced at the Savoy Mansions. Besides these works Messrs. Verity and Sons have at the present time upwards of 35 smaller installations or wiring works in progress, including the Earl of Dysart, per General Webber; Sir David Salomons, Bart.; the Royal College of Surgeons; rewiring of the Isthmian Club, Piccadilly; also Sir William M'Cormack's house; wiring for 1,200 lights for Lord Walsingham's chambers in Piccadilly, Mr. Peter Robinson's private house, Mr. D'Oyly Carte's private house, Mr. Mather's (of Messrs. Mather and Platt), and Dr. Lennox Browne's. Another work just completed is the complete re-wiring of the Junior United Service Club, about 340 lights; the whole of this work, including the manufacture of new electroliers and fittings throughout the place, was completed in three weeks. Messrs. Verity and Sons are also making the principal electroliers for the Glasgow Municipal Buildings, and have recently completed some fittings for Her Majesty's yachts "Victoria and Albert" and the "Osborne." In addition to the above, the Holloway College has been fitted with 340 additional lights, and the Avenue Theatre with 600 lights.

Ipswich.—"'The Council are of opinion that facilities for obtaining electric light and power should be afforded to the inhabitants of Ipswich.' The Corporation, in making this statement," says the *East Anglian Daily Times*, "accurately represented the opinion of the inhabitants. Authorities and people are agreed, and an electric lighting company is ready to go ahead, but the terrible red-tapeist comes in the way. Messrs. Laurence, Paris and Scott, more or less connected with whom in the enterprise are believed to be the great firms of Fowler of Leeds and Ransomes of Ipswich, applied to the Corporation for power to make two little tunnels, about a foot square, along each side of Tavern-street, next the pavement, with the object of running their electric cables along them, and supplying the houses on either side. The tunnels would simply occupy a narrow space along the channels of the street, and very little trouble could arise from their construction. The Corporation were willing that the cables should be laid, but before granting the authority decided to take counsel's opinion. A very simple thing it seems, granting a company permission to lay a cable along a street, but counsel, on being applied to, declared the proposal fraught with danger. All sorts of technical and legal difficulties might arise. We are not the master of our own streets, though we think we are. Counsel averred that it would be dangerous to grant the proposed permission, and recommended that the electric lighting engineers be compelled to obtain a Provisional Order. When the Provisional Order is obtained the engineers are masters, not the town. We cannot give permission; it must be taken from us by application to an official in London. Some obscure clerk there, after the necessary rigmarole has been gone through, can grant Messrs. Laurence, Paris and Scott the power which the Corporation of Ipswich dare not give them. They will then be as it were above the Corporation—independent of them, with absolute rights over the little subways. Fine fun for somebody who draws a salary to give these permits, but not a very sensible thing for a modern town. In the second place, to obtain a Provisional Order will cause a great delay. The electric engineers must lose the winter, all salaries and establishment expenses running on for an extra twelve months, greatly increasing the ultimate cost of the electric light. There will be the expense also of the Provisional Order, and such luxuries are not to be had for nothing. The more the light costs the promoters and manufacturers, the more they must charge the public." These remarks of the *East Anglian Daily Times* are for the most part of a decidedly sensible character.

Birmingham.—At the meeting of the Town Council on Friday last, Alderman Pollock moved "That the consideration of the notice given on behalf of Messrs. Chamberlain and Hookham of their intention to apply to the Board of Trade, under the provisions of the Electric Lighting Acts, for a provisional order empowering them to supply electricity for public and private purposes within this borough, be deferred; and that it be an instruction to the General Purposes Committee to inquire into the whole question of the supply of electricity, and to report to this Council thereon, and particularly as to the advisability or otherwise of the Corporation, as the local authority, themselves acquiring the power to supply electricity within this borough." There seemed to be an erroneous impression abroad, namely, that after the committee declined to give their consent to the provisional order, the matter must be deferred for another year. That, however, was not so. It was not necessary that the consent should be obtained before February. An important matter for consideration was whether the Corporation themselves would apply for a provisional order, as they were very reluctant that anyone should interfere with the management of the streets. At the same time the resolution ought not to be regarded as being hostile to the introduction of the electric light; on the contrary, he thought there was a strong feeling that some steps should be taken in that direction, but the Council would have to see not only what was good for the promoters, but for the public. They must also take care that if electricity were supplied it should be supplied on reasonable terms. If the General Purposes Committee should recommend that the Council should apply for a provisional order, then it was certain that there would be a delay of twelve months, because they could not apply before next November. In 1882 a report was presented by the Gas Committee recommending the Council not to interfere in the matter of the supply of electricity, but to enable others to do so. He had received that morning a letter from Messrs. Chamberlain and Hookham's solicitors, stating that their clients offered at any time within two years to sell their undertaking, works, and plant to the Corporation at actual cost price. This offer enabled the Corporation, if they wished, to postpone their final decision, but afforded the best guarantee that the promoters' outlay would be judicious and honest.—Alderman Johnson, as chairman of the General Purposes Committee, seconded the motion, and echoed the sentiments of Alderman Pollack that the committee had but one desire, that the experiment should be tried, and that it should be tried after due consideration of the question as to whether the Corporation should undertake it or whether they should grant a license to an outside applicant.—Alderman White said it seemed to him that the time had come when the Council should take up the question of electric lighting. He believed that the Council did right a few years ago in deferring the subject; but the time had now arrived when they might reconsider it, and they should also bear in mind the proposal of Messrs. Chamberlain and Hookham to sell the undertaking to them if they desired. He thought that was a guarantee of good faith.—Mr. Fallows pointed out that electric lighting was very extensively carried on in America, so that it could no longer be regarded as an experiment.—Mr. Osler hoped the committee would not approach the subject with any prejudice in favour of gas, but with a desire to give every facility for the development of electric lighting in Birmingham. Knowing something about the difficulties of electric lighting, he trusted the Corporation would not undertake it if they could get an adequate guarantee that they would keep perfect control of the streets.—Alderman Pollack, in reply, said the committee would take care to report before February on the subject.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 7.)

Elementary Theory of the Induction Coil.—Aiming rather at the elucidation of principles than very copious treatment, we shall consider the problem of the induction coil in its simplest form. Let there be two bobbins of wire in suitable positions for producing mutual induction and without iron cores. Let the constant inductance of the first or primary be denoted by L and its ohmic resistance R, and the similar quantities for the second or secondary coil be N and S, and let M be the co-efficient of mutual inductance.*

Let there be a source of constant electromotive force, E, which can be applied or withdrawn from the primary circuit. We denote by x the strength of the current in the primary at any time t after closing the primary circuit by applying the battery to it. Also we denote by y the current in the secondary circuit at any time reckoned from the same zero.

If, then, at any instant the currents are x and y, the following state of things exists in the circuits.

The electromotive force E is the impressed force on the primary circuit.

The effective electromotive force producing the current x is Rx, the counter-electromotive force of self-induction is $-L\frac{dx}{dt}$, the counter-electromotive force of mutual induction due to the current y at that instant in the secondary circuit is $-M\frac{dy}{dt}$, and hence the relation which at any instant holds good between these quantities is

$$L\frac{dx}{dt}+M\frac{dy}{dt}+Rx=E,$$

which is an expression of the fact that the external electromotive force balances the internal electromotive forces, and the effective electromotive force driving the current.

Similarly, for the secondary circuit we have an induced electromotive force due to the induction of the primary on the secondary equal to $M\frac{dx}{dt}$ and a counter-electromotive force of self-induction $N\frac{dy}{dt}$; hence

$$N\frac{dy}{dt}+M\frac{dx}{dt}+Sy=0,$$

since there is no external impressed electromotive force. The complete solution of the problem of finding the currents x and y at any instant is obtained by the solution of these simultaneous differential equations—

$$L\frac{dy}{dt}+M\frac{dy}{dt}+Rx=E,$$

$$N\frac{dy}{dt}+M\frac{dx}{dt}+Sy=0.$$

As our object is not specially to deal with difficulties of analysis we shall simplify the problem by supposing that the two circuits are similar in every respect. This makes $R=S$ and $L=N$, and the equations become

$$L\frac{dx}{dt}+M\frac{dy}{dt}+Rx=E \quad . \quad . \quad . \quad . \quad \text{(i.)}$$

$$L\frac{dy}{dt}+M\frac{dx}{dt}+Ry=0 \quad . \quad . \quad . \quad . \quad \text{(ii.)}$$

Bearing in mind that L is in ordinary parlance the "number of lines of force" which are linked with the primary circuit due to unit current in its own circuit, and that M signifies the number of lines of force which are common to both, or linked in with both circuits, when unit current flows in each, we see that M can never be greater than L, but that under all circumstances we must have

$$M < \text{or} = L,$$

also $$M < \text{or} = N;$$

hence $$M^2 < \text{or} = LN,$$

or $LN - M^2$ always a positive quantity, and the maximum value which the co-efficient of mutual inductance M can have is $\sqrt{LN}$, or the square root of the product of the self-inductances.

In order to separate the differentials in (i.) and (ii.) we differentiate each equation with respect to t, and obtain—

$$L\frac{d^2x}{dt^2}+M\frac{d^2y}{dt^2}+R\frac{dx}{dt}=0 \quad . \quad . \quad . \quad \text{(iii.)}$$

$$L\frac{d^2y}{dt^2}+M\frac{d^2x}{dt^2}+R\frac{dy}{dt}=0 \quad . \quad . \quad . \quad \text{(iv.)}$$

Multiply (iii.) by L, (iv.) by $-M$, and (i.) by R, and then, adding the three equations together, we obtain—

$$\frac{d^2x}{dt^2}+\frac{2LR}{L^2-M^2}\frac{dx}{dt}+\frac{R^2}{L^2-M^2}x=\frac{ER}{L^2-M^2} \quad . \quad . \quad \text{(A)}$$

and a similar elimination gives us

$$\frac{d^2y}{dt^2}+\frac{2LR}{L^2-M^2}\frac{dy}{dt}+\frac{R^2}{L^2-M^2}y=0 \quad . \quad . \quad . \quad . \quad \text{(B)}$$

We have now separated the differentials in x and y, and the solution of these equations depends, as is well known,* upon the solution of an auxiliary quadratic equation—

$$m^2+\frac{2RL}{L^2-M^2}m+\frac{R^2}{L^2-M^2}=0,$$

the solution of which is—

$$m=-\frac{R}{L+M}, \text{ or } -\frac{R}{L-M}.$$

Hence the general solution of (A) and (B) is—

$$x=Ae^{-\frac{Rt}{L+M}}+Be^{-\frac{Rt}{L-M}}+\frac{E}{R}, \quad . \quad . \quad . \quad \text{(5)}$$

and

$$y=A'e^{-\frac{Rt}{L+M}}+B'e^{-\frac{Rt}{L-M}} \quad . \quad . \quad . \quad . \quad . \quad \text{(6)}$$

where A, B, A', B' are constants of integration to be determined from the circumstances of the flow. To do this, however, a preliminary discussion is necessary. Let us suppose that the primary current is fully established, and has a steady value I, and hence that MI lines of force penetrate through the secondary circuit. This quantity is then the electro-magnetic momentum of the secondary circuit, because when the current in the primary is steady there is no current in the secondary circuit.

Let us now suppose that the primary circuit is broken, and that the circumstances of the "break" are such that all these MI lines of force are removed at a uniform rate in a small time, δt, from the secondary circuit.

During this time δt an electromotive force will operate upon the secondary circuit equal in magnitude to $-\frac{MI}{\delta t}$, or to the rate of decrease of the included lines of force. We have seen in Chap. II. that when an electromotive force E acts on a circuit of inductance L and resistance R that the current i at any time t after the commencement of the application of the electromotive force is given by the equation

$$i=\frac{E}{R}(1-e^{-\frac{R}{L}t}).$$

Now, in the case considered the inductance and resistance of the secondary circuit are L and R, and the impressed electromotive force applied during a time δt is $\frac{MI}{\delta t}$. Hence, at any time *during* the interval of time δt the value of the secondary current is given by the equation

$$i=\frac{MI}{\delta t R}(1-e^{-\frac{R}{L}t}).$$

* Continental writers often call L and N the potentials of the bobbins on themselves, and M the potential of one bobbin on the other.

* *See* Boole's "Differential Equations," p. 192, 2nd Edition.

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This gives us the value of the inverse induced current at any time during the breaking of the primary. Expand the above expression by the exponential theorem and it becomes

$$i = \frac{M}{L} I - \frac{M}{L^2} \frac{R \delta t}{1 \cdot 2} + \frac{M}{L^3} \frac{R^2 \delta t^2}{1 \cdot 2 \cdot 3} - \text{etc.}$$

At the instant when the removal of lines of force or the cessation of the induction through the secondary takes place the impressed electromotive force ceases and the secondary current begins to die away. If we suppose the "break" of the primary to be very sudden, δt becomes practically zero, and we have

$$i = \frac{M}{L} I ;$$

that is to say, the secondary current starts with a value equal to $\frac{M}{L}$ of that of the steady primary.

The state of things in the secondary circuit immediately *after* the break of the primary is, then, this: the electromotive impulse due to stoppage of the primary has generated a current of initial value $\frac{M}{L} I$ in the secondary, but there is no impressed electromotive in the secondary circuit. If at any instant after the break the current in the secondary circuit is i, the law of decay of this current is expressed by the equation

$$L \frac{di}{dt} + R i = 0.$$

The solution of this is

$$i = C e^{-\frac{R}{L} t}$$

and the constant C is found from the condition that when $t = 0$ $i = \frac{M}{L} I$. Hence we have

$$i = \frac{M}{L} I e^{-\frac{R}{L} t} \quad \ldots \ldots \quad (7)$$

This gives us the value of the direct or "break"-induced current in the secondary at any instant after the break of the primary. Graphically, this may be represented by a curve, such as that in Fig. 10. During the time O T in which the primary is being broken the induced electromotive force is creating an induced current, the rising strength of which is represented by the rise O P. The time occupied by the break δt is O T. As O T is diminished in value, the magnitude of the maximum ordinate P T, approximates to $\frac{M}{L} I$, and this is the initial value of the inverse secondary current when the break is very sudden. After the break the current decays away along a path represented by P Q, and becomes zero only after an infinite time.

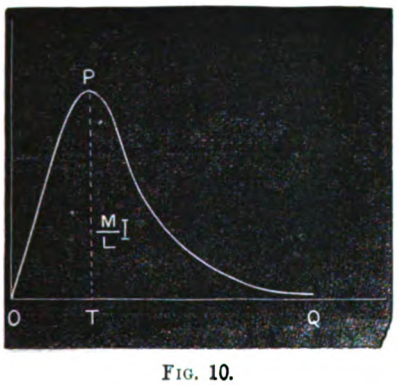

FIG. 10.

The whole quantity of the induced current is obtained by integrating equation (7) with respect to the time from zero to infinity, thus:

$$\int_0^\infty i \, dt = \int_0^\infty \frac{M}{L} I e^{-\frac{R}{L} t} = \frac{M I}{R}.$$

We see, then, that both the maximum value and whole quantity of the direct secondary current are proportional to the coefficient of mutual induction and to the strength of the primary current, and, moreover, that the whole quantity of electricity set in motion in a secondary circuit of total resistance R by suddenly removing from it M I lines of force is equal to the quotient of number of lines removed by the total resistance of the secondary circuit.

If the induced current is sent through a galvanometer the indications are proportional to the magnitude of $\frac{M I}{R}$. If, however, the induced current is employed to magnetise steel needles, the magnetisation acquired is dependent upon the magnitude of $\frac{M I}{L}$, and is therefore greater in proportion as the coefficient of self-induction of the secondary circuit is less. Lord Rayleigh has pointed this out,* and shown by experiment that within certain limits the magnetising effect of the break-induced current on steel needles is *greater* the smaller the number of turns of which the secondary consists, the opposite being, of course, true of the galvanometer. The galvanometer takes account of the induced current as a whole; whilst the magnetising power depends mainly on the magnitude of the current at the first moment of its formation, without regard to the time which it takes to subside.

(To be continued.)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.SC.

(Concluded from page 18.)

The latest researches of Dr. Hertz on electrical oscillations of which accounts have been published at present are described in a Paper "On Electro-Dynamic Waves in Air, and their Reflection," in Wiedemann's *Annalen*, Vol. XXXIV., p. 609. The author had been endeavouring to find a more striking and direct proof of the finite velocity of propagation of electro-dynamic waves than those which he had hitherto given, for, though these are quite sufficient to establish the fact, they can only be properly appreciated by one who has obtained a grasp of the results of the entire series of researches.

In many of the experiments which have been described Dr. Hertz had noticed the appearance of sparks at points in the secondary conductor, where it was clear from geometrical considerations that they could not be due to direct action, and it was observed that this occurred chiefly in the neighbourhood of solid obstacles. It was found, moreover, that in most positions of the secondary conductor the feeble sparks produced at a great distance from the primary became considerably stronger in the vicinity of a solid wall, but disappeared with considerable suddenness quite close to the wall. The most obvious explanation of these experiments was that the waves of inductive action were reflected from the wall and interfered with the direct waves, especially as it was found that the phenomena became more distinct when the circumstances were such as to favour reflection to the greatest possible extent. Dr. Hertz therefore determined upon a thorough investigation of the phenomena.

The experiments were made in the Physical Lecture Theatre, which is 15 metres in length, 14 metres in width, and 6 metres in height. Two rows of iron columns, running parallel to the sides of the room, would collectively act almost like a solid wall towards electro-dynamic action, so that the available width of the room was only 8·5 metres. All pendant gas fittings were removed, and the room left empty, with the exception of wooden tables and forms, which would not exert any appreciable disturbing effect. The end wall, from which the waves were to be reflected, was of solid sandstone, with two

* *Phil. Mag.*, Ser. 4, Vol. XXXIX., 1870, p. 429.

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doors in it, and the numerous gas pipes attached to it gave it, to a certain extent, the character of a conducting surface, and this was increased by fastening to it a sheet of zinc 4 metres high and 2 metres broad, connected by wires to the gas pipes and a neighbouring water pipe. Special care was taken to provide an escape for the electricity at the upper and lower extremities of the zinc plate, where a certain accumulation of electricity was to be expected.

The primary conductor was the same that was employed in the experiments described in my last Paper, and was placed at a distance of 13 metres from the zinc plate, and, therefore, two metres from the wall at the other end of the room. The conducting wire was placed vertically, so that the E.M.F.s to be considered increased and diminished in a vertical direction. The centre of the primary conductor was 2·5 metres above the floor of the room, which left a clear space for the observations above the tables and benches. The point of intersection of the reflecting surface with the perpendicular from the centre of the primary conductor will be called the point of incidence, and the experiments were limited to the neighbourhood of this point, as the investigation of waves striking the wall at a considerable angle would be complicated by the differences in their polarisation. The plane of vibration was therefore parallel to the reflecting surface, and the plane of the waves was perpendicular to it, and passed through the point of incidence.

The secondary conductor consisted of the circle of 35 centimetres radius, which has been already described. It was movable about an axis through its centre perpendicular to its plane, and the axis itself was movable in a horizontal plane about a vertical axis. In most of the experiments the secondary conductor was held

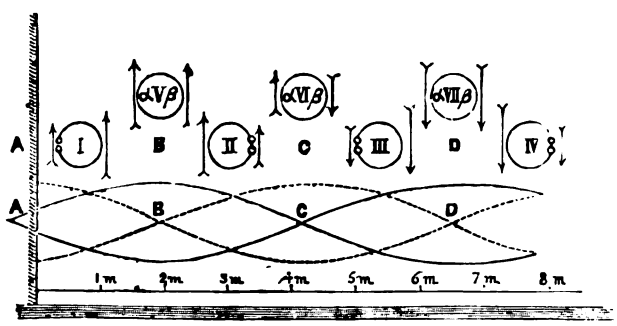

FIG. 12.

in the hand by its insulating wooden support, as this was the most convenient way of bringing it into the various positions required. The results of these experiments, however, had to be checked by observations made with the observer at a greater distance from the secondary, as the neighbourhood of his body exerted a slight influence upon the phenomena. The sparks were distinct enough to be observed at a distance of several metres when the room was darkened, but when the room remained light they were practically invisible even when the observer was quite close to the secondary.

When the centre of the secondary was placed in the line of incidence and with its plane in the plane of vibration, and the air-space was turned first towards the reflecting wall and then away from it, a considerable difference was generally observed in the strength of the sparks in the two positions. At a distance of about 0·8 metre from the wall the sparks were much stronger when the air space was directed towards the wall, and its length could be adjusted so that while there was a steady stream of sparks when in this position, they disappeared entirely when the air space was directed away from the wall. These phenomena were reversed at a distance of 3 metres, and recurred, as in the first case, at a distance of 5·5 metres. At a distance of 8 metres the sparks were stronger when the air space was turned away from the wall, as at the distance of 3 metres, but the difference was not so well marked. When the distance was increased beyond 8 metres no further reversal took place, owing to the increase in the direct effect of the primary oscillation and the complicated distribution of the E.M.F. in its neighbourhood.

The positions I., II., III., and IV. (Fig. 12) of the secondary circle are those in which the sparks were strongest, the distance from the wall being shown by the horizontal scale at the foot. When the secondary circle was in the positions V., VI., and VII., the sparks were equally strong in both positions of the air space, and quite close to the wall the difference between the sparking in the two positions again diminished. Therefore the points A, B, C, D in the diagram may in a certain sense be regarded as nodes. The distance between two of these points must not, however, be taken as the half-wave length, for if all the electrical motions changed their directions on passing through one of these points the phenomena observed in the secondary circuit would be repeated without variation, since the direction of oscillation in the air space is indifferent.

The conclusion to be drawn from the experiments is that in passing any one of these points part of the action is reversed, while another part is not. The experimental results, however, warrant the assumption that twice the distance between two of these points is equal to the half-wave length, and when this assumption is made the phenomena can be fully explained.

For, suppose a wave of E.M.F., with oscillations in a vertical direction, to impinge upon the wall, and to be reflected with only slightly diminished intensity, thus giving rise to stationary waves. If the wall were a perfect conductor, a node would necessarily be formed in its surface, for at the boundary and in the interior of a perfect conductor the E.M.F. must be infinitely small. The wall cannot, however, be considered as a perfect conductor, for it was not metallic throughout, and the portion which was metallic was not of any great extent. The E.M.F. would therefore have a finite value at its surface, and would be in the direction of the impinging waves. The node, which in the case of perfect conductivity would occur at the surface of the wall, would, therefore, actually be situated a little behind it, as shown at A in the diagram. If, then, twice the distance A B —that is to say, the distance A C—is half the wave-length the steady waves will be as represented by the continuous lines in Fig. 12. The E.M.F.s acting on each side of the circles, in the positions I., II., III., and IV., will therefore at a given moment be represented in magnitude and direction by the arrows on each side of them in the diagram. If, therefore, in the neighbourhood of a node the air space is turned towards the node, the strongest E.M.F. in the circle will act under more favourable conditions against a weaker one under less favourable conditions. If, however, the air space is turned away from the node, the stronger E.M.F. acts under less favourable conditions against a weaker one under more favourable conditions. In the latter case the resultant action must be less than in the former, whichever of the two E.M.F.s has the greater effect, which explains the change of sign of the phenomenon at each quarter-wave length.

This explanation is further confirmed by the consideration that if it is the true one the change of sign at the points B and D must take place in quite a different manner from that of the point C. The E.M.F.s, acting on the secondary circle, in the positions V., VI., and VII., are shown by the corresponding arrows, and it is clear that in the positions B and D, if the air space is turned from one side to the other, the vibration will change its direction round the circle, and, therefore, the sparking must during the rotation vanish either once or an uneven number of times. In the position C, however, the direction of vibration remains unaltered, and therefore the sparks must disappear an even number of times, or not at all.

The experiments showed that at B and D the sparking diminished as the air space receded from α, vanished at the highest point, and again attained its original value at the point β. At C, on the other hand, the sparking continued throughout the rotation, being a little stronger at the highest and lowest points. If, then, there is any change of sign in the position C, it must occur with very much smaller displacements than in the other positions, so that in any case there is a distinction such as required between this and the other two cases.

Another very direct proof of the truth of Dr. Hertz's representation of the nature of the waves was obtained. If the secondary circle lies in the plane of the waves instead of in the plane of vibration, the E.M.F. must be equal at all points of the circle, and for a given position of the air space, the sparking must be directly proportional to its intensity. When the experiment was made it was found, as expected, that at all

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distances the sparking vanished at the highest and lowest points of the circle, and attained a maximum value at the points in the horizontal plane through the point of incidence.

The air space was then placed at such a point and close to the wall and was then moved slowly away from the wall, when it was found that while there was no sparking quite close to the metal plate, it began at a very small distance from it, rapidly increased, reached a maximum at the point B, and then diminished again. At C the sparking again became excessively feeble, and increased as the circle was moved still further away. The sparking continued steadily to increase after this, as the motion of the circle was continued in the same direction, owing, as before, to the direct action of the primary oscillation.

The curves shown by the continuous lines in Fig. 12 were obtained from the results of these experiments, the ordinates representing the intensity of the sparks at the distances represented by the corresponding abscissæ.

The existence in the electrical waves of nodes at A and C, and of loops at B and D, is fully established by the experiments which have been described; but in another sense the points B and D may be regarded as nodes, for they are the nodal points of a stationary wave of magnetic induction which, according to theory, accompanies the electrical wave and lags a quarter wave-length behind it.

This can easily be shown to follow from the experiments, for when the secondary circle is placed in the plane of vibration with the air space at its highest point, there will be no sparking if the E.M.F. is uniform throughout the space occupied by the secondary. This can only take place if the E.M.F. varies from point to point of the circle, and if its integral round the circle differs from zero. This integral is proportional to the number of magnetic lines of force passing backwards and forwards across the circle, and the intensity of the sparks may be considered as giving a measure of the magnetic induction, which is perpendicular to the plane of the circle. Now in this position vigorous sparking was observed close to the wall, diminishing rapidly to zero as the point B was approached, then increasing to a maximum at C, falling to a well-marked minimum at D, and finally increasing continuously as the secondary approached still nearer to the primary. If the intensities of these sparks are taken as ordinates, positive and negative, and the distances from the wall as abscissæ, the curve shown by the dotted lines in Fig. 12 is obtained, which therefore represents the magnetic waves.

The phenomena observed in the first series of experiments described in this Paper may therefore be regarded as due to the resultant electric and magnetic actions. The former changes sign at A and C, the latter at B and D, so that at each of these points one part of the action changes sign, while the other does not, and therefore the resultant action which is their product must change sign at each of these points, as was found to be the case.

When the secondary circle was in the plane of vibration the sparking in the vicinity of the wall was observed to be a maximum on the side towards the wall, and a minimum at the opposite side, and as the circle was turned from one position to the other there was found to be no point at which the sparks disappeared. As the distance from the wall was increased the sparks on the remote side gradually became weaker, and vanished at a distance of 1·08 metre from the wall. When the circle was carried further in the same direction the sparks appeared again on the side remote from the wall, but were always weaker than on the side next to it; the sparking, however, no longer passed from a maximum to a minimum merely, but vanished during the rotation once in the upper and once in the lower half of the circle. The two null points gradually receded from their original coincident positions, until at the point B they occurred at the highest and lowest points of the circle. As the circle was moved further in the same direction, the null points passed over to the side next to the wall, and approached each other again, until when the centre was at a distance of 2·35 metres from the wall the two null points were again coincident. B must be exactly halfway between this point and the similar point previously observed, which gives 1·72 metre as the distance of B from the wall, a result which agrees, within a few centimetres, with that obtained by direct observation. Moving further in the direction of C, the sparking at different points of the circle became more nearly equal, until at C it was exactly so. In this position there was no null point, and as the distance was further increased the phenomena recurred in the same order as before.

Dr. Hertz found that the position of C could be determined within a few centimetres, the determinations of its distance from the wall varying from 4·10 to 4·15 metres; he gives its most probable value as 4·12 metres. The point B could not be observed with any exactness, the direct determinations varying from 6 to 7·5 metres as its distance from the wall. It could, however, be determined indirectly, for the distance between B and C being found to be 2·4 metres, taking this as the true value, A must have been 0·68 metre behind the surface of the wall, and 6·52 metres in front of it. The half-wave length would be 4·8 metres, and by an indirect method it was found to be 4·5 metres, so that the two results agree fairly well. Taking the mean of these as the true value, and the velocity of light as the velocity of propagation, gives as the vibration period of the apparatus 1·55 hundred-millionths of a second, instead of 1·4 hundred-millionths, which was the theoretically calculated value.

A second series of experiments were made with a smaller apparatus, and though the measurements could not be made with as much exactness as those already described, the results showed clearly that the position of the nodes depends only on the dimensions of the conductors and not on the material of the wall.

Dr. Hertz states that after some practice he succeeded in obtaining indications of reflection from each of the walls. He was also able to obtain distinct evidence of reflection from one of the iron columns in the room, and of the existence of electrodynamic shadows on the side of the column remote from the primary.

In the preceding experiments the secondary conductor was always placed between the wall and the primary conductor—that is to say, in a space in which the direct and reflected rays were travelling in opposite directions, and gave rise to stationary waves by their interference.

He next placed the primary conductor between the wall and the secondary, so that the latter was in a space in which the direct and reflected waves were travelling in the same direction. This would necessarily give rise to a resultant wave, the intensity of which would depend on the difference in phase of the two interfering waves. In order to obtain distinct results it was necessary that the two waves should be of approximately equal intensities, and therefore the distance of the primary from the wall had to be small in comparison with the extent of the latter, and also in comparison with its distance from the secondary.

To fulfil these conditions the secondary was placed at a distance of 14 metres from the reflecting wall, and, therefore, about 1 metre from the opposite one, with its plane in the plane of vibration, and its air space directed towards the nearest wall, in order to make the conditions as favourable as possible for the production of sparks. The primary was placed parallel to its former position, and at a perpendicular distance of about 30 centimetres from the centre of the reflecting metallic plate. The sparks observed in the secondary were then very feeble, and the air space was increased until they disappeared. The primary conductor was then gradually moved away from the wall, when isolated sparks were soon observed in the secondary, passing into a continuous stream when the primary was between 1·5 and 2 metres from the wall—that is, at the point B. This might have been supposed to be due to the decrease in the distance between the two conductors, except that as the primary conductor was moved still further from the wall the sparking again diminished, and disappeared when the primary was at the point C. After passing this point the sparking continually increased as the primary approached nearer to the secondary. These experiments were found to be easy to repeat with smaller apparatus, and the results obtained confirmed the former conclusion, that the position of the nodes depends only on the dimensions of the conductor, and not on the material of the reflecting wall.

Dr. Hertz points out that these phenomena, which are exactly analogous to the acoustical experiment of approaching a vibrat-

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ing tuning-fork to a wall, when the sound is weakened in certain positions and strengthened in others, and also to the optical phenomena illustrated in Lloyd's form of Fresnel's mirror experiments; and as these are accepted as arguments tending to prove that sound and light are due to vibration, his investigations give a strong support to the theory that the propagation of electro-magnetic induction also takes place by means of waves. They, therefore, afford a confirmation of the Faraday-Maxwell theory of electrical action. He points out, however, that Maxwell's, in common with other electrical theories, leads to the conclusion that electricity travels through wires with the velocity of light, a conclusion which his experiments show to be untrue. He states that he intends to make this contradiction between theory and experiment the subject of further investigation.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section II.—Electro-Magnetic Fields.

(*Continued from page 821, Vol. XXI.*)

135. *Electro-Magnetisation of Annealed Iron Wire.*—In order to observe the magnetisation of a piece of iron when there is practically no demagnetising effect from its own poles, it has been stated that a rod or wire must be selected whose length is at least 300 times its diameter. Now, if the magnetic moment is measured by either of the two methods of Gauss already detailed (para. 125), the iron wire tested must be very small in diameter, as it is not convenient to test a very long wire by these methods. And the strength of pole developed in a wire of small diameter is necessarily very small even when the iron has acquired a high magnetisation, in consequence of

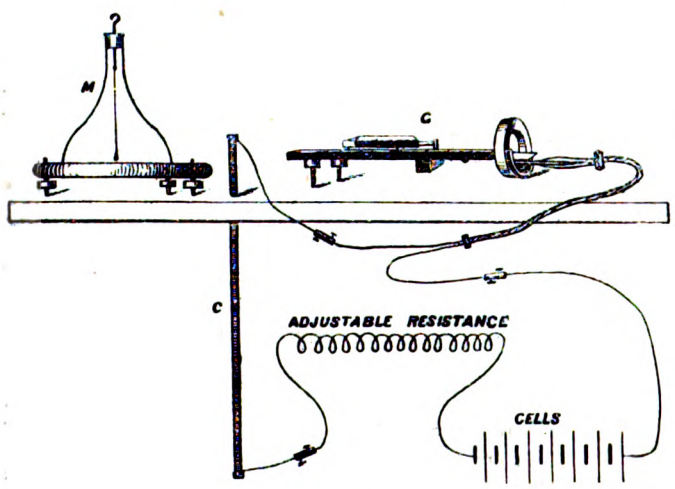

Fig. 116.

which the magnetometer can only be deflected to very small angles. With a light mirror attached to the needle, the amplitude of the deflections can be considerably increased by a ray of light reflected from the mirror on to a screen, and in this manner very small movements of the needle can be accurately observed. We are here, however, employing a magnetometer without a mirror attachment, and it is therefore advisable to arrange matters so that the needle is deflected to a considerable angle, say to 50 deg. or 60 deg., when the iron is near its highest magnetisation. The intermediate deflections can then be read with ease and accuracy. This may be effected conveniently by using a long core and placing it vertically, as shown at C (Fig. 116). As large a diameter as No. 11 B.W.G. iron wire may be used for a core 3ft. long, and yet be over the necessary ratio of length to diameter. This gives sufficient sectional area of iron to develop, at high magnetisations, enough strength of pole to strongly deflect the needle, the top end of the core being within 20 centimetres from the needle. In this diagram, C is the magnetising coil wound round a brass tube, and fixed vertically by passing it through a hole in the table. The iron wire core of the same length as the tube should slip easily into it, and the upper end of the latter be fixed a little above the level of the magnometer needle, in order that the pole, which is formed at a little distance from the end, may act more nearly in a horizontal line with the needle. As the iron becomes more magnetised the poles move up more to the ends, but are always some slight distance off, even when most strongly magnetised. By this method, the upper pole acts powerfully on the needle; and with a long core the action of the lower pole is very feeble. If we neglect the action of the lower pole, the intensity of field at the needle, placed r centimetres away from the upper pole, is

$$\frac{m}{r^2} \text{ C.-G.-S. units,}$$

where m is the strength of pole (*see* paras. 108 and 109). But where accuracy is required the action of the lower pole must be taken into account. Taking the point of p (Fig. 117) as the centre of the magnetometer needle and SN as the magnetised core, it will be seen that the lower pole (R centimetres from p) would repel a unit north pole at p with a force of

$$\frac{m}{R^2} \text{ dynes.}$$

But this force is in an oblique direction, and the needle moving in a horizontal plane is only influenced by horizontal forces. It is therefore only the horizontal component of the above force that we have to deal with. Resolving by the parallelogram of forces we have by similar triangles

$$\text{horizontal component} : \frac{m}{R^2} :: r : R,$$

whence the horizontal force $= \frac{m\,r}{R^3}$ dynes.

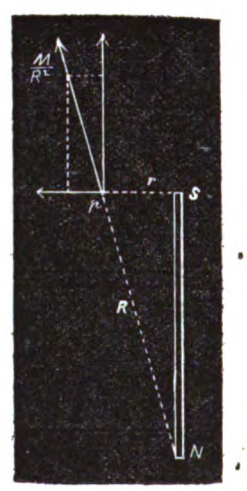

Fig. 117.

The resultant force f at the needle is then the difference between the forces due to each pole, viz.:—

$$\frac{m}{r^2} - \frac{m\,r}{R^3} \text{ dynes.}$$

Now, the force in dynes on unit pole at a point is the same thing as the intensity of field at that point, and, therefore, the above value of f represents the strength of field at the needle centre due to both poles of the core. This field also acts on the needle at right angles to the earth's horizontal field H, and, therefore (by para. 119)

$$f = H \tan \alpha,$$

where α is the angular deflection of needle. Glancing at the figure it will be noticed that the end of the magnetometer needle is viewed, the earth's meridian being supposed to be at right angles to the plane of the paper, and the magnetising coil C being placed east or west of the needle.

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Equating the above values of f, and reducing by simple algebra, we have

$$m = \frac{H \tan \alpha r^2}{1 - \left(\frac{r}{R}\right)^3},$$

which gives the strength of each pole in C.-G.-S. units, and from which the magnetisation may be calculated by

$$I = \frac{m}{a} \text{ C.-G.-S. units,}$$

where a is the sectional area of the core in square centimetres.

The cubed fraction in the denominator is the ratio of the distances of the poles of the core from the needle, and this fraction is small when the core is long and placed near to the needle. If the cube of this fraction is very small and is neglected it will be seen that the formula represents the action of the upper pole alone.

The manner of taking the test is precisely the same as that already detailed for the short iron rod. In the figure the adjustable resistance is shown conventionally, the practical apparatus having already been detailed in para. 131 and Fig. 112. The following practical example may serve as a guide to work by:—A brass tube of three millimetres bore and 90 centimetres long was first served round with an insulating covering of brown paper and then wrapped round carefully with No. 18 silk-covered copper wire. This took 657 turns of wire in all, or 7·3 turns per centimetre. The current was obtained from a maximum number of 12 secondary cells through two adjustable resistances, one of German silver wire (Fig. 112) and the other of water, the latter being for the smaller alterations in resistance. Measurements of the current strength were taken on a Thomson-graded galvanometer G (Fig. 116), the manner of using which has been described. The controlling magnet was not used in any of the readings, and therefore the current was found by

$$C = \cdot 18 \frac{D}{P} \text{ amperes,}$$

where D is the deflection and P the position of the needle-box (para. 132). A curve was then plotted on squared paper from the readings in the same manner as described for the last curve, the vertical ordinates being magnetometer deflections and the horizontal ordinates the magnetising forces, calculated in ampere-turns *per foot*. The reason of this is that the last curve (Fig. 115) was plotted from readings taken with a magnetising coil one foot long, and therefore the magnetising forces in ampere-turns expressed on that curve are actually ampere-turns *per foot*. Now we wish to compare the rates of magnetisation of the two cores under test for a given series of magnetising forces, and therefore to be able to compare the two curves together we plot the magnetising forces exerted on the core at present under consideration in the same units as those employed on the previous core (para. 134), viz., ampere-turns per foot. We have already noted (para. 130) that the magnetising fore in C.-G.-S. units is equivalent to

$$\frac{\text{ampere-turns}}{\text{length of coil (centimetres)}} \times 1{\cdot}257;$$

that is, the number of ampere-turns per centimetre multiplied by 1·257, from which it may be noticed that magnetising forces are proportional to the number of current-turns per unit of length. When comparing two or more coils of *the same length* the strength of field set up by them or their magnetising forces are proportional simply to their respective number of ampere-turns, but when dealing with coils of different lengths the simple statement of the number of ampere-turns on each offers no basis of comparison between them; we must know the number of ampere-turns for a certain definite length of coil in each. (We are referring to cylindrically-wound coils, as generally used for electro-magnets, not ring-shape coils, as in galvanometers.) For example, take two coils, each wound with one layer of wire of similar size and around bobbins of similar diameter; one bobbin being twice the length of the other. If the same current is passed through both, the number of ampere-turns in the former is twice that in the latter, and the length of wire wound on is also twice as much, but the magnetic field developed by each, or their respective magnetising forces, are equal, for we have the same number of ampere-turns per unit of length in each. Again, take two coils, each wound with one layer of wire of similar size and around bobbins of similar length; one bobbin being twice the diameter of the other. If the same current is passed through both, the number of ampere-turns per unit of length is the same in each, and therefore the magnetic field developed by each is the same, although the length of wire wound on the former is twice that on the latter. And, further, if we take two exactly similar bobbins and wind any size wire on each, the magnetic fields developed are proportional to the number of ampere-turns on each; and if the current is the same in both, the fields are proportional simply to the number of turns or to the length of wire wound on each. The remarks in para. 128 allude to this latter and more simple case.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, November 16th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read, "Experiments on Beams." By Mr. ED. C. DE SEGUNDO, C.E.

TUESDAY, November 20th.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture, "The Throat and Voice." By Mr. W. D. HALLIBURTON, M.D., D.Sc.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on Mr. BEAUMONT'S Paper on "Friction-Brake Dynamometers."

WEDNESDAY, November 21st.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting at the Institution of Civil Engineers. Papers will be read on "Results of an Investigation of the Phenomena of English Thunderstorms during the Years 1857-59." By Mr. G. J. SYMONS, F.R.S. "Notes on the Meeting of the International Meteorological Committee at Zurich in September, 1888." By ROBERT H. SCOTT, M.A., F.R.S.

SOCIETY OF ARTS.

8 p.m. First Meeting of the 150th Session of the Society. Opening Address by the Duke of ABERCORN, C.B., Chairman of the Council.

THURSDAY, November 22nd.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

8 p.m. Ordinary General Meeting. "On a System of Electrical Distribution." By Mr. HENRY EDMUNDS, Member.

SATURDAY, November 24th.

PHYSICAL SOCIETY.

3 p.m. "On the Measurement of the Luminosity of Coloured Surfaces." By Capt. ABNEY, R.E., F.R.S.

"On the Suppressed Dimensions of Physical Quantities." By Prof. RÜCKER, F.R.S.

The Electric Telegraph Association of Victoria.—The third annual meeting of the Victorian Electric Telegraph Association took place in Melbourne in the first week of September, there being a large attendance. The committee, in presenting their annual report to the members of the association, expressed their regret that notwithstanding their strenuous exertions to improve the position of operations by securing a modification of the grading system adopted by the Public Service Board, they had not succeeded, but good work had been done with regard to many other matters. The members present accorded a unanimous and hearty vote of thanks to the retiring committee for their efforts to improve the position of operators. The election of officers and committee was then proceeded with, and resulted as follows:—President, Mr. H. A. Krone; vice-president, Mr. H. J. Allan; secretary, Mr. Joseph Tatchell; treasurer, Mr. M. H. Fitzgerald; committee, Messrs. F. Peacock, William Taylor, F. J. Edgar, T. Howard, J. R. Jackson and J. K. Brown.

Brussels.—The installation at the Théâtre de la Monnaie is to be enlarged, and accumulators are to be put in at the Maison du Roi. These accumulators, like those at the Théâtre de la Monnaie, will be charged from the central station at Laeken.

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The Electrician.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

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For Foreign Parts and Colonies:— Within Postal Union	6 6	12 6	24 0
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THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received.

CONTENTS OF THE CURRENT NUMBER.

Notes	35	The Society of Telegraph Engineers and Electricians— On Ocean Temperatures in Relation to Submarine Cables. By W. Lant Carpenter, B.A., B.Sc. *Discussion.* Illustrated	48
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued	40	Electric Traction in Birmingham.—Trial of the Julien Car	51
Hertz's Researches on Electrical Oscillations. By G. W. de Tunzelmann, B.Sc. Illustrated. Concluded	41	Legal Intelligence	51
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued	44	American Notes	52
Meetings of Scientific Societies, &c.	45	Notes from Brussels	53
Overhead Wires for Electric Lighting	46	Correspondence. Illustrated	54
Manufacture of Copper Wire by Elmore's Electro-Burnishing Process	47	Some New Instruments by the Consolidated Telephone Construction and Maintenance Company. Illustrated	58
On the Conduction of Alloys and Solid Sulphides. By Dr. J. H. Gladstone, F.R.S., and W. Hibbert	48	Companies' Meetings, &c.— West India and Panama Telegraph Company	59
		Australasian Electric Light, Power and Storage Co.	60
		City Notes, &c.	63
		Companies' Share List	64

VOLUME XXI. OF "THE ELECTRICIAN."

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OVERHEAD WIRES FOR ELECTRIC LIGHTING.

In view of the extensive projects for lighting the metropolis by means of electricity now in course of development, it need not surprise us that the public are already alive to the question as to how the wiring is to be done. According to the *Standard* of Tuesday last questions are about to be put to the President of the Board of Trade with regard to the intentions of the newly-formed Electric Lighting Companies, it being feared that their plans will involve an enormous addition to the existing overhead wires. Probably the question of their safety will also be raised, and will have to be answered. The subject is of considerable importance at this juncture, and desiring that it may be dealt with in a thoroughly fair and unprejudiced manner we hasten to offer some observations upon it in the interests both of the undertakers and the public at large.

Much ill-feeling has been aroused by the unrestricted and unregulated proceedings of the Telephone Companies, whose overhead systems might have been rendered as inoffensive to public taste as they are harmless to public safety, had Parliament consented to grant legal rights—subject to reasonable restrictions—in the first instance. Left to themselves the companies allege that they have made the best of their position, and that they would have offended far less if their powers had been a little greater. In other words, their wires often follow fantastic and overcrowded routes, simply through the difficulty of obtaining way-leaves for less objectionable courses. No doubt this is true in many instances; and, at all events, the general result has been so unsatisfactory that the absence of legislative sanction and control has long been a matter of profound regret. That being the case, it is fortunate, perhaps, that in respect to overhead electric light wires the issue has been raised at an early stage, and hopes may be entertained that, acting on the powers conferred upon it by Parliament, the Board of Trade will, concurrently with its regulations, grant powers which will place the electric lighting industry on a better footing than the

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telephone industry, both in respect to its rights and its duties. The Electric Light Companies will not object to regulations; and it will be seen from our last week's issue that the Board of Trade is far from objecting to regulate them; but something must be conceded in return, and if any doubt still exist as to whether the powers conferred by licenses and provisional orders for laying wires underground apply to their erection overhead now is the time to remove such doubt. We may say at once that we do not look to the overhead system alone for a complete solution of the problem of distributing electricity, but we do think that it will always find a place in high-tension systems. Probably the ultimate solution will consist in a combination of the two—underground conduits in the most crowded districts, and overhead lines for the outlying portions. But in the earlier stages of the enterprise it seems almost essential that overhead wires be largely resorted to. Gradually, as the business grows, they may be supplemented, if not superseded, by conduits or subways.

The alarm expressed in the *Standard's* notice that the number of overhead wires will be enormously increased has, however, but a slender foundation. In the first place, to provide individuals with separate telephone services a proportionate number of separate overhead wires is required; whereas, to supply the same number of individuals with electricity would require a very much smaller number of wires overhead, a single outgoing and return wire often serving for the needs of a whole district. In reality, what additions may be required for electric lighting purposes for a long time to come will make scarcely any appreciable difference to the overhead wire system of the metropolis. As to their relative safety, something may and probably will be said in opposition to the electric light wires. On this point we shall speak presently; but, as almost all the outdoor installations hitherto permitted have been on the overhead principle, and as no thoroughly satisfactory method of burying the wires underground has yet been devised, it is not to be supposed that the former system will be forbidden, or that electric lighting will be suppressed altogether, because its current is not perfectly harmless like that of telephony. For many reasons, apart from the question of safety, we have advocated the placing of wires underground in all populous towns; and to a very large extent this has been successfully accomplished by the Post Office Telegraph Department. But in this case the problem is of a very different and much more difficult character, and, although we are anxious to see the experiment of underground conduits for all kinds of conductors tried on a considerable scale, yet we cannot wish to see the progress of electric lighting delayed because of the few additional housetop wires which it would involve.

Of course the example of American cities, and particularly of New York, will be cited against us. There the electric wires of every description have been ordered underground; and in some places they have been summarily pulled down where the owners declined or neglected to obey the law. Misgivings, however, are already entertained that action in this matter has been too precipitate, and that to get rid of one form of nuisance the municipal authorities have exposed the public to another and perhaps a more dangerous one. The condition of the street wires in America was becoming simply intolerable. Our New York correspondent's letters have so graphically described the state of things arising out of unlimited competition among the telephone, telegraph, and electrical companies peculiar to the States, that we need not refer to it more particularly here. Necessary, however, as was some drastic measure of relief, and ingenious as have been the devices for lodging the offending wires beneath the pavements, the effect on lighting wires individually, and on signalling wires collectively, is by no means encouraging. To provide separate subways for these would be even more difficult in London than in New York, and they would certainly be exposed to the same sort of risks as those which are mentioned in our correspondent's letter from that city this week. Explosions of gas accumulated in the cable conduits are reported from New York, Boston, and elsewhere; and whether due to lightning or to other causes, such accidents sharply illustrate the troubles attending the laying of wires underground.

Any comparison, however, between this country and America at once provokes the observation that whatever we decide to do, whether we put our wires underground or carry them overhead, there is one thing we shall not do—we shall not scamp the work. Our own electrical engineers—we speak of men in the front rank of the profession—are not faultless; but their errors are chiefly due to lack of experience, never to culpable and reckless indifference to the consequences of bad workmanship. Now, these are precisely the terms we in this country would naturally apply to the installations of which we have authentic accounts from America. Of course, there are many conspicuous examples of an opposite kind which we ourselves are only too glad to imitate; but we have their own confession for it that in many instances the work of American electrical engineers is incomparably inferior to ours. A reference to Mr. HAROLD BROWN'S letter which we print this week affords some illustrations of the kind we allude to, and which he characterises in language which Englishmen will not consider too strong. Mr. BROWN'S facts and deductions as regards alternating currents may be taken with some allowance for his well-known prejudice against that system of supply; but there is plenty of independent testimony as to the "criminal carelessness" on which he so warmly animadverts. And what we have to say about it in relation to the matter now under discussion is that the dangers which the States have had to legislate upon are to a great extent non-existent and not to be apprehended here. More than one hundred miles of overhead electric light wires are already working in London alone, and there has been no serious accident traceable to bad workmanship, carelessness, or want of supervision. The Board of Trade can be trusted to frame and enforce regulations sufficiently strict; and with this guarantee the public may be content to allow the necessary erections for any electric light supply that London will require for some years to come.

MANUFACTURE OF COPPER WIRE BY ELMORE'S ELECTRO-BURNISHING PROCESS.

Messrs. Elmore, whose electro-burnishing process for the manufacture of copper pipes has been recently described in our columns, are now making wire for electrical purposes from the copper so obtained. The method adopted is by the use of a specially-constructed machine to cut the copper pipe made by their process into a wire of square section by a spiral cut running from end to end of the pipe. As this square wire is cut it is drawn through the first hole of a wire-drawing plate, and subsequently drawn down to any gauge required.

The copper has been submitted to a series of mechanical tests by Prof. Unwin and Prof. Kennedy, in the Engineering Laboratories of the Central Institution and of University College respectively, and also by Messrs. Clark, Forde and Taylor, and by Mr. C. J. Simmons, who have also submitted it to a series of tests for electrical conductivity.

The tensile strength of some of the specimens of hard copper was remarkably high, the greatest values being in the case of two strips tested by Prof. Unwin, the breaking strains for which were respectively 39·29 tons per square inch, with an

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ultimate elongation of 5·1 per cent., and 41·28 tons per square inch, with an ultimate elongation of 7 per cent.

According to Messrs. Clark, Forde and Taylor's electrical tests on both annealed and hard-drawn wire, the mean value of the conductivity of the annealed wire in terms of Matthiessen's standard for annealed copper (taken as 100), and of the hard-drawn wire in terms of Matthiessen's standard for hard copper, in each case came out 102·38. The details of the experiments are given in the accompanying table :—

Diameter in inches.	Gauge (approximate) B.W.G.	Conductivity of annealed wire in terms of standard for annealed copper.	Conductivity of hard wire in terms of standard for hard copper.
0·113	12	102·33	102·46
0·0825	14	—	102·51
0·057	17	102·35	102·31
0·049	18	102·45	102·26

The temperature coefficient of this exceptionally pure copper is found to be distinctly higher than that given by Matthiessen for the purest copper he was able to obtain, a result which was to be expected.

ON THE CONDUCTION OF ALLOYS AND SOLID SULPHIDES.*

BY DR. J. H. GLADSTONE, F.R.S., AND W. HIBBERT.

This Paper concerns the nature of the conductivity of alloys and sulphides. They may either conduct the electric current directly, like metals, or electrolytically whilst they are undergoing decomposition. If a current is passed through an alloy any decomposition should manifest itself in a change in the resistance. The well-known alloys of lead, tin, cadmium, and bismuth, some of which melt in boiling water, exhibit no change of resistance if the current passes through them, or if any does appear it is very slight, and has nothing to do with the direction of the current. The alloys were contained in U-tubes. If, however, a little more lead, ½ per cent. or 1 per cent., was added to the alloy in the one limb a change was observed, though Prof. Roberts, in his allied experiments which were brought before the Manchester meeting, had not found any change. In another series of experiments solid particles, coarse or fine, of galena and other sulphides were packed with plates of bright silver between them, and the current passed through the group. Some of these sulphides are fairly good conductors. In a few cases the silver became a little tarnished; but, on the whole, the experiments prove that ordinary sulphides of the formula MS are real conductors, and not electrolytes. The cuprous and silver sulphides of the formula M_2S, on the contrary, behave like electrolytes. Thallium also forms a sulphur compound of the formula M_2S. It was therefore interesting to inquire into its behaviour; and it has been ascertained, as Prof. Crookes had already observed, that this sulphide becomes a better conductor at higher temperatures, and also that the polarisation increases. Another thallium compound, Tl_2S_3, is soft and plastic, and a very poor conductor. When placed in the tube with platinum or silver electrodes it showed a very slight polarisation at higher temperatures; but it became hard, indicating that a molecular change had occurred, which was not of the nature of a direct decomposition, as no sulphur could be extracted.

* Abstract of Paper read before the British Association meeting (Section A) at Bath, September, 1888.

The Montreux Disaster.—A *Times* telegram says that the accident at Montreux last week was due to the telephone. The reservoir which furnished the motive power of the Chillon electric tramway being so full as to cause apprehensions, the man in charge was telephoned to in the words, "Ne mettez plus d'eau." He did not catch the first two words, and consequently turned on more water; the result being that the reservoir burst, with loss of life and great damage to property.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of the Society last week the following discussion took place upon Mr. Lant Carpenter's Paper "On Ocean Temperatures in Relation to Submarine Cables," which was published in our previous issue :—

Mr. ALEXANDER SIEMENS said that they had listened to an exceedingly interesting Paper from Mr. Carpenter, and with that gentleman's permission he would give some practical illustration of the ocean temperatures which his own firm had observed. He would use a diagram (Fig. 1) of temperatures which were observed at the Weston-Waterville section of the Commercial Cable Company, that company having given permission to publish it. The observations were made by Siemens Brothers' electrician, Mr. Frank Jacob. The length of the cable was about 320 nautical miles, and it enclosed two conductors. The method adopted to make the measurement was that for the conductor resistance the two cores were connected in series; and for the dielectric resistance the one pole of the battery was connected to one conductor and the other pole to the other conductor. That method of measurement was devised by Mr. Frank Jacob to eliminate the influence of earth currents. The lower curves on the diagram showed the variations in temperature throughout the three years, and gave the conductor resistance direct and as they were taken from the instrument. The upper curves showed the insulation resistance. The observations were taken as the mean of ten minutes' electrification by readings at intervals of every ten seconds, but as the earth currents were eliminated by the method of testing which he had described the electrification was as regular as when testing the cable at the works during the manufacture. These curves showed very accurate measurements through the fact of two cores being

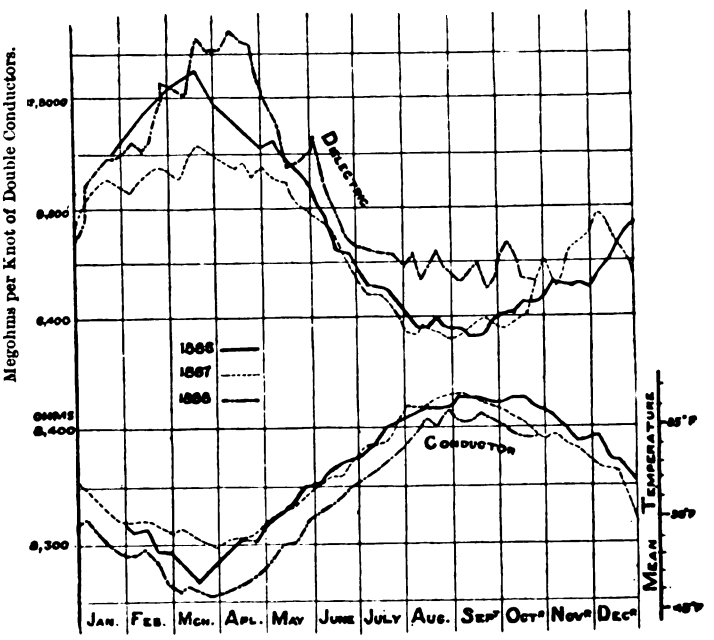

Fig. 1.—Annual Variation in Temperature, Weston-Waterville Cable.

available. In the diagram three curves were given representing the measurements for 1886, 1887 and 1888 respectively. The resistance of the copper conductor while the cable was being manufactured at the works was tested at a uniform resistance of 50°F., and by adding up the different lengths of the coils as they were tested the total resistance was arrived at, which represented 50°F. For instance, in the beginning of May, 1886 and 1887, the cable was exactly at the same temperature as in the tanks at the works. Then the well-known curve gave the variation in temperature. They would observe a very curious thing—that the observations in 1886 and 1887 were almost identical. In the beginning of June, they saw the two lines almost fall together, and in September the two lines were exceedingly similar. Then, a little further on, they would see that in 1888, which was rather a cold year, it showed a conductor resistance much lower all through the year, at least as far as the curve went, than it was in the two preceding years. Every variation in the conductor resistance was shown in the resistance of the dielectric, only it was always in the opposite direction. The maximum and the minimum they would see was in March and in September, in all three years. In March the water was coldest, in September the water was hottest. If the temperatures all along the cable had been exactly alike, the temperature calculated from the copper resistance and the temperature calculated from the resistance of the dielectric would be the same. But that was not the case. That seemed to show that the water for the whole length of the cable was not at a uniform temperature; in October, 1886, a measurement was taken at 120 miles from the Irish end by a thermometer in the way described by Mr. Carpenter. The actual temperature was found to be 52°F., whereas the resistance of the cable gave 56°F. This discrepancy seemed to point out that the waters of the Bristol Channel had a great influence, and varied.

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more during the year in their temperature than the water of the deeper section cable. It was, perhaps, useful to point out that at 50°F. the insulation resistance was just over 70 megohms for the total length of 320 knots. They must bear in mind that he had two conductors connected to the instrument; therefore the insulation resistance per knot was 70 times 160, or 11,200 megohms. In a similar manner Mr. Jacob had furnished him with the average temperature of some of the Atlantic cables which his own firm had laid, and it was curious that in four of them the average temperature came out as 37°F. and in the fifth it was 38°—it lay in so much shallower water. Of course, in these measurements the shore ends were included, and therefore the temperature was a little higher than Mr. Carpenter had shown the temperature of the bottom of the Atlantic to be; but if they bore in mind that there were these shore ends he thought that the agreement of the two measurements was very close (applause).

The PRESIDENT: What is the greatest depth you got when the Weston-Waterville was laid?

Mr. SIEMENS: Only 100 fathoms.

Mr. STALLIBRASS thought the Siemens electrical thermometer had not been used as much as it should have been. On the telegraph ships there was every facility for using this thermometer, and he was sure that excellent results would be got from it. He thought that the Miller-Casella thermometer had many disadvantages. It required great care to successfully use this thermometer. Very often the indices moved with the least jerk, and except in careful hands he thought the thermometer was to a certain extent unreliable. The Siemens thermometer had many advantages. For shallow water he thought that the capsizing Negretti and Zambra thermometer was, perhaps, more suitable, and he preferred to use it with the leaden messenger, which travelled down the sounding line and released the locking arrangement. He thought if this thermometer was used to any extent it would be worth while to have a correction table. Although the amount of mercury which was measured on the capsising of the instrument was very small, still it was affected by temperature, and if, as he had often seen the thermometer used, it was read to a temperature of considerably over 80 degrees, the expansion of that comparatively small amount of mercury was well worth considering. A friend of his had experimented on this in his laboratory and had made a correction table, but he did not think it had ever been used (applause).

Mr. ALEXANDER SIEMENS: We have also a temperature calculation —66°F.—about a cable which is laid in the Red Sea, and I will add the result to my remarks in the *Journal*, so as to put on record how that agrees with the measurements spoken to by Mr. Carpenter.

Captain WHARTON said that he had very little to remark strictly germane to the subject of the Paper—that was, anything in connection with the submarine cables, of which he knew nothing. He could only say a few words about the apparatus that was used to ascertain the temperatures. He thoroughly agreed with the last speaker that the Miller-Casella had disadvantages (he would not say many disadvantages, however), and that if they could get a more perfect instrument they would gladly use it. The Magnaghi instrument did not answer in deep water. Their experiments tended to show that in about two out of three soundings the thermometer reversed at some point before the one at which they wished it to reverse, and when it came up showed entirely wrong. They had, therefore, more or less discarded it as being entirely unreliable; but the Miller-Casella gave very good results at a general depth. Of course if there was a colder stratum above a hotter no doubt the result was unreliable, but it was very rarely that the indices got shaken down—at least, they had found it so. When the serial temperature was taken, they could judge very fairly from that alone whether any particular observation was incorrect, and it was very rarely indeed, owing to the perfection with which these thermometers are made, that those errors were apparent, and for the present he did not think that they could have any better instrument. He was not acquainted with Sir William Siemens's beautiful sounding instrument; but he was afraid that it was hardly adapted for use on board their vessels, where they had not electric apparatus nor officers sufficiently trained in electricity to use it. He had last week received a letter from one of their surveying vessels in the South Pacific. Captain Aldrich wrote that he had obtained a very deep sounding of 4,430 fathoms to the south of the Friendly Islands, and that he was lucky enough to bring up his thermometer from the bottom quite safe. In the soundings of the "Challenger" at nearly the same depth four thermometers were sent to the bottom, and three of them came up broken. Captain Aldrich only sent one of them to the bottom, and he was lucky enough to bring it up safe with a temperature of 33·7.

Mr. CHARLES BRIGHT: As regards the conductivity of copper, referred to by Mr. Lant Carpenter, I would remark that the 102·38 per cent. mentioned by him is at the present time quite an ordinary conductivity for copper intended for telegraphic purposes, and, consequently, the correct coefficient for variation of resistance by temperature is frequently somewhat higher than that given for Dr. Mathiessen's standard, pointing to the desirability of a fresh standard being adopted. Inasmuch as the resistance of gutta-percha is effected so much more sensitively by a change of temperature than that of copper, it is sometimes a good plan to calculate the temperature by the variation of the dielectric resistance in the case of gutta-percha cores, as well as by that of the conductor, merely as an occasional check on the coefficient for variation by temperature of the resistance of the copper conductor. By reason of the effect of pressure on the resistance of gutta-percha too much reliance cannot be put in such results, especially owing to the possibility of the presence of an incipient fault. Moreover, this plan is not, as a rule, carried out in submarine cores, owing to the additional effect of the weight or pressure of the water above the cable on the resistance of any fibrous materials such as gutta-percha, and to the fact that no such effect occurs visibly on any metal substances, such as copper, whose hardness prevents their being condensed by any physical agencies. No theory has been advanced in the Paper as to the different physical effect produced by a change of temperature which causes the resistance of metals such as copper to be decreased by a cold temperature, and that of vegetable fibrous substances, like gutta-percha or India-rubber, to be increased thereby, and *vice versâ*. The physical effect is presumably the same in both cases as that of the pressure of the water, only materially more marked. The effect of pressure is that of condensation. In the case of a metal no sensible change is produced thereby owing to the already highly condensed state; but with vegetable fibrous substances, like gutta-percha and India-rubber, the effect is highly sensible. These materials are naturally of a porous character, but when subjected to pressure become less so, and consequently tend to absorb less water, the presence of which, especially as regards salt water, naturally lowers the resistance of such materials; moreover, the mere fact of increased homogeneity is sufficient to account for increased resistance by less loss of current laterally. The late Sir William Siemens first demonstrated the effect of pressure on insulating substances in a Paper on the subject read before the British Association, in 1863, based on experiments on the gutta-percha core of the Malta-Alexandria cable of the year before, as well as on the Carthegena-Oran gutta-percha core and on certain India-rubber cores. Herein he pointed out how the resistance of gutta-percha was materially increased by pressure and in direct proportion to the degree of the same, which was varied as desired in the pressure tanks of Reid. The formula given in the Paper before us, expressing the increase of the resistance of gutta-percha by pressure, was given by Siemens as the result based on these experiments, where the coefficient 0·00023 was the amount of increase in resistance found to occur on a unit resistance by a unit pound pressure. It will be seen, therefore, that this formula was not one of the many introductions due to Mr. Latimer Clark, as stated in the Paper, but is due rather to Sir W. Siemens. Messrs. Bright and Clark tested the first Persian Gulf core under pressure, finding the gutta-percha to be increased in resistance 2·6 per cent. for every 100lb. pressure; whereas Siemen's experiments showed the dielectric resistance of the Malta-Alexandria core to be increased only 2·3 per cent. thereby. In Bright and Clark's experiments 600lb. was, however, the maximum pressure, being equivalent to only 224 fathoms of sea water, whereas in those of Siemens a pressure equal to about 1,700 fathoms was applied. The most useful way in practice of expressing the increase of the resistance of gutta-percha by pressure on submergence is, I think, to say that it is increased 6·2 per cent. for every 100 fathoms depth of sea water. Most forms of India-rubber cores are more absorptive than a gutta-percha core, owing largely to the fact that the rubber, as a rule, is of necessity laid on the wire in strips either spirally or longitudinally, thus involving a continuous seam, instead of being applied round the wire in a homogeneous tubular form, as in the case of a gutta-percha core. Siemens found that some forms of masticated India-rubber were decreased in resistance by pressure at a rate about one-fourth that at which gutta-percha is increased by a corresponding amount. The formula expressing the decrease of resistance of such India-rubber by pressure would be

$$R_p = R\,[1 - (0{\cdot}000061 \times p\ \text{lb.})],$$

where R is the original resistance, 0·000061 the coefficient of decrease of resistance on unit resistance (1 megohm) by unit pressure (1lb.), p the number of pounds pressure applied, and R, the increased resistance by pressure. Fairbairn found that some forms of India-rubber were slightly increased in resistance by pressure. In any case the resistance of any description of India-rubber can be but little improved by pressure due to submergence, as compared with gutta-percha, owing to its higher absorptive power. Most mixtures of vulcanised India-rubber, being more homogeneous and less absorptive (like gutta-percha), are not, however, affected materially by pressure in either direction. The nature of the physical change produced by a change of temperature on vegetable substances of the gutta-percha and India-rubber order is that of cold contracting the material and heat expanding it. Thus, by contraction the pores of the material are closed by its molecules being brought closer together, and consequently it is more compact in its texture, its absorptive tendency is proportionally decreased, and as a result the electrical conductivity is decreased. The effect of heat on fibrous materials such as gutta-percha and India-rubber is that of expansion separating the pores and thus increasing the absorptive tendency and lowering the resistance by this and by the decreased homogeneity of the texture. The fact that temperature exerts an opposite influence on the conductivity of metals and vegetable materials cannot be satisfactorily explained physically. In 1863, Messrs. Bright and Clark conducted a series of experiments on the gutta-percha core of the Persian Gulf cable in order to determine precisely the nature and degree of the variation of the resistance of gutta-percha due to temperature. The result of these experiments showed that the resistance of gutta-percha was increased very considerably by a decrease of temperature, and *vice versâ*—not in simple proportion to each alteration of temperature, but by compound interest, as shown in the logarithmic curve in the diagram before us, similar to that which was drawn up as the result of these experiments. The resistance of India-rubber is somewhat similarly increased by a fall of temperature and decreased by a rise thereof, but mixtures of India-rubber when vulcanised are considerably less affected by temperature than gutta-percha; indeed, the coefficient for variation of resistance by temperature of the favourite form of Hooper's vulcanised rubber is less than half that denoting the variation of gutta-percha resistance. The degree of variation of resistance by temperature (as also by pressure) of India-rubber, even when vulcanised, differs very much, however, for the different "mixtures." The amount of variation by pressure and temperature depends principally on the degree of specific resistance; thus, mixtures with a low resistance are very much more affected than those with a very high resistance (in the same way that gutta-percha, which has a much lower resistance than Hooper's rubber, is more affected by temperature). Thus the coefficient for

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variation of resistance by temperature of some forms of vulcanised India-rubber with a resistance but little above that of gutta-percha is more than double that for vulcanised rubber with the highest resistance (which is often twenty times as much as that of gutta-percha at 75°F.) or nearly as much as that for gutta-percha. The same applies, only to a less extent, as regards the different gums of gutta-percha. For this reason, the coefficient of variation of resistance, represented by the curve in the diagram before us, cannot be said to apply to gutta-percha in general, but only to the particular gum on which the experiments were made from which the coefficients corresponding to the curve were deduced. Owing to the alteration in the gums at different times it would be desirable, strictly speaking, to calculate a separate coefficient for variation of resistance by temperature for each separate core made. Considering, however, that the resistance of gutta-percha varies so much by age, owing to other circumstances besides changes of temperature, such calculations and corrections of resistance for temperature can only be correct for the time being—*i.e.*, at which the variation of resistance by temperature was noted. I do not think this fact is sufficiently appreciated. Temperature affects the electrostatic capacity of a cable in so far as it affects the resistance of the insulating medium; that is to say, materials with the highest resistance usually offer facilities for the lowest capacity, and *vice versâ*. Moreover, when the resistance of gutta-percha is increased, as by a decrease of temperature, its capacity also is, as a result, at the same time decreased (owing to a specific change in the material), though in a much less degree. It would probably be decreased in a much more proportional degree to the increase of resistance but for the fact of the cold temperature having also, by contraction, the effect of bringing the two plates of the Leyden jar closer together. The capacity of India-rubber is less altered than gutta-percha by temperature; in fact, scarcely at all. Some mixtures are increased and others decreased in capacity thereby; but all in a very small degree. In his experiments with pressure, Sir W. Siemens did not find that the capacity of either gutta-percha or India-rubber was affected by pressure. It is probable, however, that pressure, inasmuch as it increases the resistance of gutta-percha, will, like a cold temperature, tend, indirectly, to be the cause of a slight decrease of capacity; but whereas pressure produces so much less effect than temperature on the resistance of gutta-percha, its effect on the capacity is imperceptible; indeed, the same counteracting tendency by condensation of the Leyden jar taking place, the capacity can, in any case, be but very slightly effected by pressure. Inasmuch as pressure tends to decrease the resistance of some forms of India-rubber it also tends to increase the capacity thereof, in the same way that a cold temperature does. When a cable with a gutta-percha insulator is submerged under a depth of 2,000 fathoms of the ocean, where the temperature is 36°F., and where the weight of sea water above it is equivalent to 5,352lb. per square inch, the insulation resistance is increased 1,145 per cent., of which 1,022 per cent. is due to the decrease of temperature from 75°F. to 36°F., and 123 per cent. to the pressure exerted on it. Thus the decrease of temperature has taken a nearly 10 times greater share in the increase of resistance than the pressure has. To take a practical example:—An original resistance of 600 megohms per knot at 75°F. at atmospheric pressure, becomes at this depth 7470·5 megohms per knot, equivalent to an increase of 6870·6 megohms, 6,737 of which is due to temperature and 738·6 to pressure. In many waters, however (such as in the Atlantic, for instance), the temperature does not fall below the said 36° F. which it very ordinarily attains at about the aforesaid 2,000 fathoms depth, so that in the case of submergence under greater depths the resistance of the dielectric will be no further increased by temperature, though it will continue to be increased by pressure in direct proportion to the increase of depth. Thus, when the same cable is submerged under a depth of 3,000 fathoms in a case where the bottom temperature at this depth is 36°F., and where the pressure of a column of water of this height is 8,028lb. to the square inch, then the resistance will by pressure be further increased by 4,598 megohms, *i.e.*, from 7470·6 megohms at 2,000 fathoms to 12068·5 at 3,000 fathoms. Thus the total increase of resistance due to the pressure of this depth is 5,336 megohms, or 889 per cent., whereas that due to the 39° decrease of temperature from 75°F. to 36°F. is 6,132 megohms, or 1,022 per cent. From this it will be seen that there is thus a material reduction in the difference between the relative effects of temperature and pressure at 3,000 fathoms as compared with that at 2,000 fathoms. In fact, at great depths pressure takes nearly as much part in increasing the dielectric resistance of a cable as temperature does, which, though it falls rapidly just below the surface, does so very gradually lower down until at a certain depth it falls no further. Vulcanised India-rubber cores especially are nearly as much decreased in dielectric resistance by pressure at great depths as by temperature, and at depths beyond 3,000 fathoms the effect of pressure is, under some circumstances, even greater than that of temperature probably.

Dr. OBACH said that some two years ago he made experiments with a number of thermometers to find out what influence pressure had on the readings. Of course, he had only low pressures at his disposal in the laboratory, but the results would give some idea as to how greatly thermometers could be influenced by pressure. He found that when a delicate chemical thermometer divided into tenths of degrees was placed in a vacuum, the mercury fell between one and two tenths of a degree, and when the pressure was increased one atmosphere it rose to about the same extent. All the thermometers behaved similarly. Therefore, for these thermometers one could only say that a difference in pressure of two atmospheres produces a difference in the reading of one-fourth to one-third of a degree centigrade, so that a pretty high influence is exercised in this way; which, for some experiments of importance—for instance, distillations in vacuo—necessitates a correction which cannot be neglected (applause).

Mr. REDGRAVE, a visitor, having obtained permission to address the meeting, said he had been engaged on many cable expeditions for one of the largest firms in the country. In taking their deep-sea temperatures they used a form of thermometer similar to the Miller-Casella made by Elliott Bros. With this instrument they had obtained temperatures in all depths from 500 to 2,500 fathoms, and had never seen a thermometer broken yet. Captain Wharton had told the meeting that a friend of his had been lucky enough to recover a thermometer from a great depth, and he had repeated the word "lucky." He (Mr. Redgrave) thought that was a very apt expression, as in taking temperatures with the thermometers attached to the ordinary sounding wire it was doubtful, at least, if you would ever recover them from deep water. On one or two occasions they had put down thermometers on deep sea buoy moorings. He remembered one case where a thermometer was down for three weeks. They could not say for certain that the stratum at the bottom was the coldest; but, assuming it to be so, and without any further correction for the instrument than comparing it with a standard, at a depth of 2,200 fathoms it recorded 37deg. He thought that bore out Mr. Lant-Carpenter's results closely. As regarded the temperature shown at the western end of the Atlantic diagram, he would like to mention a fact probably unknown to many present. The copper resistance of a 3-cored cable laid along the Nova Scotian coast showed a temperature of 29°·5 in the month of August. Having three conductors they had special facilities for checking this result, and although it was discredited by many at the time, the test was repeated and confirmed by an eminent electrician (now dead), Mr. J. C. Laws. Mr. Lant-Carpenter's explanation of the existence of that cold shelf of water would account for this phenomenon.

Captain WHARTON explained that in using the word lucky he had referred to the very great depth, which induced a pressure of five tons upon the thermometer, which was a very different thing to the 2½ tons to which Mr. Redgrave's thermometer was subjected. He thought it was a triumph to have constructed an instrument which was able to stand such an enormous pressure. They used galvanised wire, and they sent down their thermometers without the slightest fear of the result. Captain Aldrich had taken something like 80 to 85 soundings (varying from 1,000 to 4,000 fathoms) in the Indian and Pacific Oceans, and he had only lost three thermometers.

Mr. CARPENTER, in reply, thanked Mr. Siemens and Mr. Redgrave for their interesting observations. The fact of being able to practically ascertain the temperature of the sea by observations on the electrical condition of a cable was exceedingly interesting, and a capital proof of the wonderful perfection to which electrical measurements had now attained. He was not quite sure whether Mr. Siemens had made it clear that the cable to which that gentleman had referred lay in really shallow water, the depth not being greater than 100 fathoms. A great deal of what had been given in the Paper related to water at very much greater depths than that. One result of the cable being in such shallow water was that it was affected by variations in the temperature of the air above the water. As far as he remembered, he believed, the conclusions arrived at in the "Challenger" and other observations was that what might be called the super-heating effect of the sun's rays did not reach lower than about 100 fathoms. They, therefore, had in their shallow-water cable a most interesting and beautiful example and illustration of the effect of air temperatures upon the water below. With regard to what Mr. Bright had said, he would point out that he was careful, in alluding to the diagram, to say that it applied to one particular cable, and he gave the name of the cable, and the particulars of it. He did not mean to imply that that should be taken as an average of insulators; but simply as one insulator, and he was quite aware that various insulators had their separate coefficients of change with regard to change of temperature. He thanked Mr. Bright for the correction that gentleman had given him with regard to the pressure law, with which he had associated the name of Dr. Latimer Clark, and he was glad to find that a great deal of the result was due to one whose memory they all respected and revered, Sir William Siemens (applause). With regard to Mr. Mordey's question, he was not aware that observations of the kind alluded to by that gentleman had been taken, although it was quite possible that they might have been. In conclusion, he thanked the meeting for the way in which they had listened to a Paper which some of them, perhaps, might have thought was a little outside the usual run of the Society's Papers (applause).

The PRESIDENT: Gentlemen, we have listened to a clear and very able Paper of a class rarely introduced to our notice, and yet particularly interesting to one section of the members of our Society—those who are engaged in submarine enterprises. I think it is well that we should at times have something especially adapted to the tastes and interests of the various classes of our members, and I thank Mr. Carpenter for having introduced it to us. I beg, therefore, to propose that you will present to him a hearty and sincere vote of thanks for the Paper which he has been kind enough to read this evening.

The vote was carried by acclamation, and the meeting adjourned to the 22nd inst.

The Electric Light at the Empire Theatre.—The success of the new ballet at the Empire Theatre is considerably enhanced by the large scale upon which the electric light has been made use of. Each of the fifty-eight members of the *corps de ballet* is supplied with a small electric lamp in the hair, the current being obtained from a small primary battery of four cells attached to the waist. These cells only weigh 3lbs., and measure about 3½in. by 2½in. The electrical arrangements are under the supervision of Mr. Richard Allbright.

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ELECTRIC TRACTION IN BIRMINGHAM.—TRIAL OF THE JULIEN CAR.

The first public trial of electricity as a motor for tramway purposes in Birmingham was made on Wednesday of last week upon the lines of the Central Tramways Company. In our issue of October 26th we gave some details of a private trial of the same car which we had recently witnessed, but the following additional particulars will be of interest. The motor, which was specially designed and built by Elwell-Parker (Limited), has a 14in. armature, and at 700 revolutions with 200 amperes is capable of developing a maximum of 40 horse-power for a short time. Its normal output is, however, only six or seven horse-power. The accumulators are 104 in number, with 39 plates in each cell, measuring 9in. by 6in. A switch is arranged to connect them all in parallel or all in series or in two intermediate groups. Double helical toothed-wheel gearing is employed, with satisfactory results. The surfaces of the teeth, which come into contact from an obtuse angle, and the cogs themselves take the shape of a right and left-handed screw. The result is that the rolling contact is practically perfect, and the strain is always distributed over several teeth. There are other improvements in detail in connection with this gearing which, however, are not yet patented. The engine is about half as long as an ordinary steam tram-car, and, like a steam engine, is enveloped with a covering which reaches within a few inches of the metals.

The conditions laid down by the Birmingham Central Tramways Company were that the engine should be able to draw the existing cars, without alteration or conversion of form, along any of their steam routes; that the cost of traction and depreciation should not exceed that of steam locomotion; and that the electrical engine should be able to perform a full day's work of sixty miles without recharge. Those familiar with the steep gradients on some of the company's lines—Bradford-street, for instance—will be alive to the difficulty experienced in meeting the requirements of the company. The engine weighs about 8½ tons, and the accumulators are large enough to enable it to perform a journey of between seventy and eighty miles. A car similar to those working on the cable tramway was attached to the engine, and was filled inside and out with passengers, including the Mayor and several members and officers of the Corporation, and directors of the company. A start was effected at about twenty minutes to three, and the engine and car proceeded at the ordinary pace of a steam engine, observing all the stops, to the town end of Bradford-street. It was felt that the crucial test was the Bradford-street-Hill, and many misgivings were expressed as to the engine mounting the severe gradient of one in seventeen. The engine, however, acquitted itself to the satisfaction of all, mounting the hill at a fair speed. The rest of the journey was easily performed without any hitch, the engine and car running into the Moseley depôt twenty-eight minutes after the start, the average time taken for the run by a steam engine.

Those who had ridden on the car then adjourned to a waiting room, and Mr. J. SMITH made a few remarks, in the course of which he explained that the Central Tramways Company were making the experiments with a view to testing the possibilities of electricity as a motor. The engine they had seen at work that day was not the ideal one—namely, the car with the motor self-contained; but half a loaf was better than no bread, and what the Central Company desired was to ascertain whether electricity could be used in the form of accumulators, could be worked at a reasonable cost, with certainty and safety, with advantage to the travelling public, and with satisfaction to the authorities of Birmingham and the district. He thought that he ought not to conclude without referring to the firm of Elwell and Parker, who had supplied the car, to the latter of whom the company owed a considerable debt of gratitude for the trouble he had taken in the matter.

Mr. PARKER, in answer to questions, said that the engine could be stored with electricity between the time it was taken in the shed at night and the time of leaving next morning. The motive power required to draw the car up Bradford-street that afternoon was about 30 horse-power. There would be less wear and tear on the metals, because the engine was nearly five tons lighter than a steam-engine.

Councillor LAWLEY PARKER, speaking for the Corporation and and other local authorities, said that he thought he was right in saying that they would rather have a car with a self-contained motor.

Mr. SMITH said that he felt sure that whilst the Corporation and other local authorities wished to take care of the convenience of the public they did not desire to lay down conditions which would make tramway traffic a loss.

Mr. HUGHES, on behalf of the Handsworth authorities, said that he should feel very grateful if the company used engines similar to that tried that afternoon upon lines in their district, for the nuisances most complained of, arising from the emission of steam and sulphur, would be done away with.

A question was asked as to the cost of electricity as compared with steam, and

Mr. SMITH said that were the cost a little greater he should not hesitate to advise his company to face any moderate expense, in the full confidence that the increased comfort of travelling, especially to the outside passengers, would induce such an increase of traffic as would recompense the company for that increased cost. At the same time he did not see, making every provision for depreciation, why the working should not be found to compare with steam in regard to cheapness.

Those present then took their places on the car and were taken back to town.

LEGAL INTELLIGENCE.

Re the Faure Electric Accumulator Company: Judgment.

In the Chancery Division of the High Court of Justice, on Tuesday last, Mr. Justice Kay delivered judgment on the summons taken out by the liquidator of the Faure Electric Accumulator Company (Limited) against the directors.

Mr. JUSTICE KAY: The liquidator of this company, which is being wound up in this court, has taken out the present summons against certain gentlemen who were formerly directors of the company, under Section 165 of the Companies Act, 1862, seeking to make them personally liable for alleged misfeasance as such directors. No imputation whatever is made on the honesty or honourable conduct of any of these gentlemen; but it is alleged that they have committed breaches of trust in making certain payments out of the moneys of the company, and in permitting the transfer of certain of its shares. The Faure Electric Accumulator Company was formed on May 13th, 1882, for the purpose of making and carrying out an agreement for the purchase of certain patents, and carrying on the business of electricians and other matters. The capital was £1,000,000, divided into 80,000 Ordinary shares of £10 each and 200,000 Deferred shares of £1 each. Article 92 authorised the directors, out of the funds of the company, to pay the necessary legal and other expenses of and incident to the promotion, formation, and registration of the company, and all other preliminary expenses of the company. Article 28 is:—"No transfer of shares not being fully paid up shall be registered unless and until the transferee is approved by the Board of directors, and the Board at their discretion may decline to register any transfer of shares upon which the company has a lien." On February 15th, 1882, the company entered into an agreement for the purchase of certain patents under which payments had to be made in shares of the company. 20,108 shares of £10 each were subsequently allotted to the general public, and in this manner all the original £10 share capital was issued except about 20,000 shares. It appears that the company got into litigation in May of that year with another company, who, they alleged, were infringing their powers. M. Philippart, who, it seems, was very familiar with the working of these patents, attended in that month at a meeting of the Board, accompanied by Mr. Pincoffs, a London stockbroker, who acted as his interpreter. Philippart was a holder both of original and Deferred shares. He had made himself very active in the company's affairs, and upon May 22, 1882, he wrote to the Board offering to take up the subscribed capital of the first issue—that is, of the £10 shares—by taking 5,000 shares himself and 5,000 by his friends, on condition that his friends should have the option till June 15 of taking up the remaining 10,000 shares, and that he (M. Philippart) should be elected a director, and that no brokerage should be paid in respect of the allotment of these shares. This was considered at a Board meeting on the next day, May 23, and declined. On that day Pincoffs wrote to the company:—"I beg to offer to place 7,500 shares of your company at par upon condition of your giving my client the option of taking the remaining 12,382 unapplied-for shares at par until June 23 next, and subject to the usual brokerage of 2s. 6d. per share to myself." The Board appear to have taken the advice of their solicitor, who advised them by a letter, which is in evidence, that there was no objection in law to the acceptance of this offer, provided the Board were satisfied of the allottee, and that the brokerage was paid by the company, and not deducted from the price of issue. Thereupon the Board assented to the proposal, and later in the day a letter was handed to them from Mr. Morris, a stockbroker, stating that he was willing to take 7,500 shares at par, and pay £2 at once, provided he had the option of taking at par on or before June 23 the balance of the unallotted shares, amounting to about 12,500, and that the Board would allow 5s. per share commission on the whole number of shares taken by him, the commission on the 7,500 to be paid at once, the commission on the shares to be paid to Mr. Pincoffs. It is stated in evidence that Morris was known to the directors to be a stock-jobber of very large means. A formal application followed, and on the same May 23 the directors allotted 7,500 £10 shares to Mr. Morris, and paid £937. 10s. to Pincoffs as commission. Subsequently, about June 17, they allotted the remaining 12,382 £10 shares to Morris, and paid £1,547. 15s. as commission to Pincoffs. They received from Morris £2 a share on this allotment—that is, nearly £40,000. In the meantime the Board, on May 24, 1882, had received notice of a charge by Philippart to Lever on all his shares in the company, and on May 30th, 1882, they had notice of an injunction as to the Deferred shares of Philippart in the company. They referred this to their solicitor, who wrote on June 17th, 1882: "The directors should consider whether in the circumstances any tranfer of shares to M. Philippart should be registered before being fully paid." On June 30th, 1882, M. Philippart was elected

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a director of the company. On September 27th the company had notice of two charging orders on M. Philippart's shares for £420 and £1,355 respectively. Mr. Morris seems to have been at this time in communication with the Board. He had been called on by them to advise, he having a large stake in the company. It appears he was desirous to transfer the shares he held, and on October 11th, 1882, the Board sanctioned, and subsequently passed a transfer of about 19,528 shares from Mr. Morris to M. Philippart. The transfer was completed on October 18th. Shortly afterwards the directors against whom this claim is made resigned. A call of £1 per share had been made, and on January 3rd, 1883, M. Philippart and his brother directors forfeited his shares, which were then about 18,500 in number, for non-payment of that call. Subsequently two other calls of £1 a share were made. On April 10, 1883, M. Philippart became bankrupt. In July, 1884, a winding-up order was made. Thirty shillings have been called up in the liquidation. The debts of the company, it is admitted, have all been paid. Claims to a large amount are outstanding, which the liquidator is resisting, and there are, I am told, some costs of the liquidation still to be provided for. The claims made by this summons are: first, damages for the alleged misfeasance of the former directors in allotting the 7,500 shares on May 25, 1882, and 12,372 shares on June 17, 1882, to Mr. Morris, a nominee of M. Philippart, or in allowing 18,500 of such shares to be transferred on October 18, 1882, to M. Philippart; and, secondly, that they may be ordered to repay the sum paid to M. Philippart for brokerage on such allotments, with interest.

His lordship, having considered the first part of the case in detail, said: I have no doubt that when the question concerning the transfer arose, it seemed to them they had no valid reason for not approving him as a transferee; they knew that he could not obtain a transfer from Morris without satisfying the very large sum of £40,000 which Morris had paid to the company. He did this, to some extent, by transferring other shares to Morris, but he must have provided a large sum in cash. Anything like corruption or dishonesty on the part of the directors being out of the question, I am unable to treat them as responsible for the consequences of permitting this transfer. Even if the act were, with the knowledge they had at the time, a grave error of judgment, there is no ground on which the Court could properly hold them liable. Upon the second point the learned judge said that he had felt much more difficulty.

Having dealt with the various aspects of the case at considerable length, he proceeded as follows:—I must declare that the respondents, the directors, who made these payments are jointly and severally liable to repay the same to the company, with interest at 4 per cent. per annum since the moneys were paid. The order will be this. The respondents (other than Philippart, against whom no relief is asked, because he is insolvent, and Mr. Ponsonby, who was not a director until after the allotment of these shares) must be ordered jointly and severally to repay the amounts paid to Pincoffs, with interest at 4 per cent. Then I refuse the summons with costs as to all the rest, except the second head, which I allow with costs; these costs to be set-off. I must direct the taxing-master to allow Mr. Ponsonby any separate costs that may be incurred—that is, any increase of costs (perhaps that is the better way to put it) by making him a respondent. The liquidator may take any costs out of the estate which may remain after the set-off, except that I must direct the taxing-master to disallow any costs of the cross-examination which he may consider excessive.

Anglo-American Brush Electric Light Corporation v. Orient Steam Navigation Company.

In this action, which came before Mr. Justice Chitty in the Court of Chancery on Tuesday last, the plaintiffs sought an injunction to restrain the defendants from an alleged infringement of their patent for the "compound winding of dynamos." The machines in question had been supplied by Messrs. King, Brown and Co., of Edinburgh, against whom the plaintiffs have entered an action in the Scotch courts. The defendants did not seriously contest the case, and in the end an injunction was issued against the infringement, an inquiry into damages was ordered, and a certificate of validity granted. The effect of this certificate is that the appeal only lies to the House of Lords. The defendants were also condemned in costs.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 3rd*, 1888.

A bad explosion in one of our down-town electrical subways a week or two ago, followed up very closely by one in Boston, has gone to show that our underground systems are not yet all that can be desired. The explosion in this city—due, it is supposed, to the ignition of gas by lightning entering along the cables—was so powerful as to lift the covers of two manholes several feet in the air, and to disrupt the paving in every direction. Evidently the precautions against the accumulation of gas are far from sufficient. The result of such an accident must be to render the conduit liable to a free inflow of both gas and water, so that it practically becomes useless. This view of the case has arrested public attention, and a more serious trouble has now developed in connection with the local Steam Heating Company. A pedestrian in the lower Broadway and its side streets, almost any day of the year, will have his eye caught here and there along the roadbeds by little jets of steam. The first suggestion to the inexperinced mind is that New York is built over a volcano, but the simple explanation of the matter is that these jets of steam come from the defective pipes of the Steam Heating Company. The effect of this escape of steam upon the wires and cables that have been placed underground has been most serious, and it is difficult to exaggerate it. I have myself a great many times passed one of the manhole covers on Broadway, and listened to the boiling going on underneath, not daring to put my hand on the manhole cover, so hot was it. From the tests made it has been proved that the temperature in some of the conduit manholes, affected by the steam leaks, has run up as high as 209 degrees. The Western Union Company has entered a warm protest against this condition of affairs, and has reported that its cables have been reduced to the consistency of jelly, and virtually boiled to pieces, so that the only remedy seems to lie in putting the cables overhead again. The president of the Steam Heating Company has hastened to explain that the trouble has been due to the use of wooden wedges instead of cast iron for holding the pipes together. The wooden wedges have shrunk from age and heat, and left the joints of the pipes open, requiring an outlay on the down-town mains in repairs of £50,000. This is an explanation which does not help matters much, as the trouble still continues. The only way out of the difficulty is either to stop the steam heating business, or not to attempt to lay electrical conduits where the steam pipes are already underground. The Board of Electrical Control will have to deal with this matter very sternly and determinedly, or there is a great probability that much of its work will soon be reduced to ridiculous failure.

A great deal of interest is taken by the public in the new electric road which is about to be run through Fulton-street, one of our busiest thoroughfares, and well as one of our narrowest and steepest. This road, for which the tracks are already laid, will be built by the Bentley-Knight Electric Company, and the conduit system will be used, the conduit having still to be laid, although immediate work on it is promised. The road will not be a long one, but from the fact that it will operate in a street which is always crowded with drays and trucks, and which in winter is liable to swamping from rain storms and snow thaws, it will be a difficult piece of work, and if successful will do much to advance the electrical conduit system in popular esteem. The material for the construction of the road is all ready, and the construction will be carried on as soon as it can be put on the ground. The site for the erection of the dynamos, boilers, &c., is virtually decided upon, and the cars which have been ordered are to be ready by December. This is another case in which the introduction of electrical appliances involves the ripping up of the street, but it is taken for granted that there is no help for it.

A recent decision in Chicago forces the last opponents of the American Bell Telephone Company to their knees, and practically wipes out all competition. It will be remembered that a little while ago a decision was rendered against the Cushman Company on the ground of infringement of Bell's patent. In spite of this decision, the Cushman people continued to operate their telephones in various places, and hence it was necessary to seek for another injunction. The contention of the defendants was that the licensees of the Bell Telephone Company had withdrawn their instruments from the towns where the infringing apparatus was at work, on the passage of a State law limiting the telephone rates. The Court held, however, that this had nothing to do with the case, and did not furnish any excuse or defence for further infringement; and the Cushman Company have now been ordered to cease and close up. This incident has served to call attention to the fact that the fight which has waged for a long time in Indiana over telephone rates has not yet come to an end. The Central Union Company, the licensees of the parent company, has just been engaged in removing some of its poles and wires at Anderson, Indiana, and the reports from various other places in the State show that the present system, which was forced upon the company, has greatly reduced the number of subscribers. At Lafayette,

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where about 300 instruments were in use, the number has fallen to less than 100, virtually depriving the service of utility and benefit. It is a great pity that this matter cannot be settled in some way, but it may be taken for granted that the telephone people will not be willing to make any concession more than they have done. To yield in Indiana would be dangerous, and would lead to attacks all along the line in pretty well every State in the Union. In Chicago itself at the present time the fight against the telephone company has been quite brisk, but the methods of agitation have been such as to provoke comment, and the law department in the city has been instructed to investigate reports to the effect that money was to exchange hands in the event of the passage by the city council of an ordinance reducing the annual rent of telephones to 75 dollars.

There is a prospect that Boston is to have a comprehensive subway system, not unlike that of New York, but under somewhat different auspices. Permission has just been granted, over the veto of the mayor, to a company to lay conduits on condition of paying to the city all excesses of their profits over 10 per cent. of the capital actually invested, and of allowing the city to run all its own wires through the conduits free of charge. The space to be occupied by each conduit is not to exceed four square feet in cross-section measurement. There has been a great deal of opposition in Boston to this scheme, which practically gives an exclusive franchise, and there is a possibility that it will still prove a bone of contention.

An interesting paper was read last week before the Boston Electric Club by Mr. T. W. Sprague on the subject of "The Application of Electricity to Mining." The Paper does not contain any facts or data that are new, but presents an interesting summary of the progress made in this field, showing some very marked and encouraging results. Mr. Sprague says that the mining business is waiting with open arms for electrical power, and that the motor must conform itself to the essential conditions before anything like success can be attained; and in illustration of this point he mentions a case of which he heard recently. A mining man sent dimensions, &c., of a level to a leading power company, asking for figures, size, cost, &c., of a motor car to draw certain loads in a tunnel. When the reply came back it was found that the motor car would occupy an entire section of the tunnel; but the power wanted was not excessive, and the proper amount of attention would unquestionably soon adapt the car to the work, and make its use feasible.

A special cable despatch in the papers this week from England announces the fact that Mr. George Westinghouse has been awarded the contract for a plant to light the City of London, to cost about $300,000. There is not much news to be obtained on the subject this week; but it is understood from the Westinghouse Company here that this order for their apparatus comes from the company lately organised by Sir John Pender, and that a portion of the apparatus is already on the ground. We are naturally very much pleased to see that American apparatus once more comes to the front, and is approved in a country like England, where judgment in such matters is so good, and where the requirements are generally considered to be so exacting.

That enterprising paper, the *New York World*, has given a striking example of the use to which the telegraph may be put in gratifying public curiosity. A series of base-ball games has been going on to decide the championship of the world, and in order to make the result known as quickly as possible the *World* erected outside its office a huge blackboard on which was drawn a sketch of the baseball ground, or "diamond," as it is technically called. Each of the two "nines" had its own colour, and each of the players of the "nine" had a numbered peg. As soon as the game started at the ground it started also on the board, one side being shown at the bat, and the other side fielding. As each run was made, so the player was moved from base to base on the board, and this was kept up until the end of the game was reached. In order that no time should be lost, a special wire was run from the ground, whether in New York, Brooklyn, Philadelphia, or St. Louis, direct to the foot of the board, where sat an operator, who, as fast as the message was sent in, dictated it to his assistant, who, in turn, made the movements on the board. In this way the spectators could follow every movement of a game being played 1,500 miles away almost as quickly as if they were on the ground itself. The public "caught on," as we say here, and every afternoon while the series of games lasted the board was surrounded by a howling crowd of thousands of enthusiasts, who cheered or groaned themselves hoarse as they followed the movements of those little pegs from hole to hole. This enterprise must have cost a large sum of money, but it paid for itself many times over in the advertising that it gave the paper.

NOTES FROM BRUSSELS.

(FROM OUR CORRESPONDENT.)

BRUSSELS, *November* 12, 1888.

The following is the full list of the awards made by the jury of the Brussels Exhibition: — Diplômes d'Honneur: The Anglo-American Brush Corporation, J. M. E. Baudot, Bouckaert and Co., Schuckert, De Khotinsky, Ganz and Co., Mourlon and Co., H. Pieper, Gaston Planté, Th. Schubart and Kornwuller, Société Anonyme l'Électrique, Société Anonyme du Phœnix, Société Industrielle d'Electricité, the Thomson-Houston International Electric Company, the Postal Telegraph Department (Belgium). Gold medals: J. Berliner, Conradty, Connoy, De Jongh, the Electrical Power Storage Company, A. and V. Flamache, Garbe, Lahmeyer and Co., Léon Hen and Co., Lacombe and Co., Ch. Mildé and Co., V. Reclus, Rickez and Co., Schorch, Société pour l'Exploitation des Cables Électriques (Switzerland), the Thomson Electric Welding Company.—Silver Medals: Boone-Carette, Ed. Buels, Chateau et Fils, Camilaff (Russia), Cass, Shaffers and William (United States), J. B. de Koker, F. A. Hesse, Konioff (Russia), Mathis-Boveroulle, Poege, Eugene Raikem, Van de Plancke Frères, G. van Herzeele, Zwarg, Walput. — Bronze Medals: C. Belot, G. Cheriot, De Chimkewitch (Russia), De Smit, Ehlis Peter, Einhart, Francotte, Hauman-Devos, C. J. Hoffmann, Roubanowitch (Russia), P. Schwenke, J. Tollebeeke.—Diplômes d'Encouragement: Cassart, De Fernelmont, De Backer, D. Kunhardt, J. Redouté, Tossens and Boonroy, Van Bunnen Frères. As announced in your last issue, the jury have thought fit to confer the highest award in their power on each firm which took part in the electric lighting of the buildings and grounds. This wholesale method of reward has naturally been much commented on here; for whatever the merits of the various systems, they were not all equally meritorious. Not only has every vestige of the competitive principle been thus destroyed, but a unique opportunity has been missed, for rarely have so many different systems of electric lighting been working side by side. M. Bandsept had a right to expect a better result from his months of labour and anxiety, and I can hardly think that even the recipients of these valuable *diplômes d'honneur* can be altogether satisfied with this strange award.

The other evening the King, accompanied by M. Vandenpeereboom, Minister of the Railway, Postal, and Telegraph Department, was present at the inauguration of the new electric light installation at the Gare du Nord. The station is lit for the present by 19 2,000 candle-power arcs and 30 750 candle-power arcs, but it is intended later on to extend the installation and greatly increase the number of lamps. One of the things insisted upon by the authorities was that matters should be arranged so as to permit of the lamps being turned on or off as desired, and their brilliancy diminished if necessary. To attain this end, all the conductors have been brought to four central points, where switches control the lamps, the light of which can be lowered, or groups of which can be turned out, the lamps having been arranged with this view in sections of five. The new light, in addition to its other advantages, will be more economical than its dispossessed rival. In spite of the important reductions made by the gas company, who supplied gas to the station at 9 centimes the cubic metre (2s. 1d. the thousand cubic feet), the annual cost of gas was 54,000fr. Now the highest estimate for the electric light is 30,000fr. As the first cost of the present installation is only 51,000fr., the authorities will recoup themselves in two years' time.

In the Grand Duchy of Luxembourg commendable enterprise is being shown in extending the use of the telephone and the electric light. The towns of Luxembourg and Arlon will shortly be connected by a telephone line, whilst Luxembourg, Echternach and Esch are all well provided with the electric light. I anticipate that before long all the *chiefs lieux de canton* will possess central lighting stations.

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CORRESPONDENCE.

ELECTRICAL THEORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A query put by Prof. Lodge on page 830 of your issue of November 2 appears to me to strike deeply into the heart of the matters now in debate. Writing (in reply to Prof. Poynting) concerning Sir Wm. Thomson's views, he asks:—"Is it not that, finding that displacement currents have no magnetic effect, therefore he ignores them? But then, *have they no magnetic effect?*" (The italics are mine.)

Let us first be quite clear what the language of the query means. Is Prof. Lodge using the term "displacement current" in the strict Maxwellian sense for that which goes on in a stationary dielectric medium (whether homogeneous or not) during the time that an electric displacement is undergoing change in its value? Or does he use the term in any wider sense, including, for example, the case of the mechanical motion of an electrostatically charged body in a dielectric medium? For the latter the term "convexion current" would appear to be preferable.

It may be useful here to refer to Maxwell's views on the matter; doubtless they are familiar both to Prof. Lodge and to Prof. Poynting, and they leave no room for ambiguity.

"The variations of electric displacement evidently constitute electric currents. These currents, however, can only exist during the variation of the displacement" (Maxwell, Art. 60). "Whatever electricity may be, and whatever we may understand by the movement of electricity, the phenomenon which we have called electric displacement is a movement of electricity in the same sense as the transference of a definite quantity of electricity through a wire is a movement of electricity, the only difference being that in the dielectric there is a force which we have called electric elasticity, which acts against the electric displacement, and forces the electricity back when the electromotive force is removed" (Art. 66). "Any increase of this displacement is equivalent, during the time of increase, to a current of positive electricity, from within outwards [referring to case of a Leyden jar, of which the inner coating is charged positively], and any diminution of the displacement is equivalent to a current in the opposite direction" (Art. 111). "We have reason for believing that even when there is no proper conduction, but merely a variation of electric displacement, as in the glass of a Leyden jar during charge or discharge, the magnetic effect of the electric movement is precisely the same" (Art. 499). "We have very little experimental evidence relating to the direct electromagnetic action of currents due to the variation of electric displacement in dielectrics, but the extreme difficulty of reconciling the laws of electromagnetism with the existence of electric currents which are not closed is one reason among many why we must admit the existence of transient currents due to the variation of displacement" (Art. 607). "One of the chief peculiarities of this treatise is the doctrine which it asserts, that the true electric current, that on which the electromagnetic phenomena depend, is not the same thing as the current of conduction, but that the time-variation of the electric displacement must be taken into account in estimating the total movement of electricity" (Art. 610).

Turning now to the case of the so-called convexion currents, it is interesting to note the explicit views both of Faraday and of Maxwell. Faraday says:—"If two balls, A and B, be electrified in opposite states and held within each other's influence, the moment they move towards each other a current, or those effects which are understood by the word current, will be produced." . . . "So, if a ball be electrified positively in the middle of a room, and be then moved in any direction, effects will be produced as if a *current* in the same direction (to use the conventional mode of expression) had existed" (*Exp. Researches*, Art. 1,643-4). Maxwell expands this notion, which he propounds first in relation to electrolysis in Art. 238, then in relation to a stream of electrified metal filings in Art. 248; and, finally, in Art. 770, says:—"If the electric surface-density and the velocity can be made so great that the magnetic force is a measurable quantity we may, at least, verify our supposition that *a moving electrified body is equivalent to an electric current.*' . . . "The electrified surface may be that of a non-conducting disc revolving in the plane of the magnetic meridian, and the magnet may be placed close to the ascending or descending portion of the disc, and protected from its electrostatic action by a screen of metal. *I am not aware that this experiment has been hitherto attempted.*" (The italics are mine.) If I am not mistaken, Maxwell was by no means definitively satisfied on this point; his equations for the mechanical force in the electromagnetic field do not contain an explicit term for convexion currents; such a term was proposed to be added to them by Prof. FitzGerald at the Southport Meeting of the British Association in 1883. But prior to this Prof. Rowland had made, in Helmholtz's laboratory at Berlin, an experiment almost identical with that suggested as crucial by Maxwell. Rowland's apparatus, which he described in the *American Journal of Science and Arts*, in 1878, consisted of a gilt ebonite disc rotating about a vertical axis with a speed of 3,660 revolutions per minute. Though there can be no question of the *bonâ fides* of Prof. Rowland, or of the significance of the numerical results obtained, it would seem desirable that so important an experiment should be repeated by other investigators, the more so as Dr. Lecher, of Vienna, entirely failed with recent apparatus to obtain the same result. On the other hand, Prof. Röntgen, using a non-gilt ebonite disc, was successful in a qualitative repetition. In these experiments an electromagnetic effect was produced by charges of electricity moving in their own plane; but this case is clearly distinct from that of an electrified ball which is being translated along a linear path. In Profs. Ayrton and Perry's well-known theory of the origin of the earth's magnetism, it is assumed that an electrified spheroid rotating on its axis exercises magnetic actions in the space interior to the charges. But in the case of the rotation of an electrified disc or spheroid about its own axis of figure, there is not produced any change of the electric displacement in the surrounding dielectric, whereas in the case of the translation of a charged ball along a linear path, there is a continuous change going on in the displacement at every point of the surrounding medium; that is to say, the translation of the charge is accompanied by displacement currents over and above its action as a mere convexion current. It would seem that what is now wanted is some direct experimental evidence whether displacement currents, apart from convexion currents, produce any electromagnetic effects. Such experiments, though possibly delicate, ought not to be impracticable.

There is, however, a third case that is not touched upon directly by Maxwell, and may possibly be included in Prof. Lodge's query. If a non-homogeneous dielectric which is under influence, and across which there exists, therefore, a certain amount of electric displacement, is internally disturbed, there will be local internal variations in the displacement from point to point, and yet there will not necessarily be any change in the total displacement between the two limiting surfaces. For example, suppose a condenser made of two large equal flat metal plates as the limiting surfaces, with a plate of glass or mica occupying only a fraction of the space between them, the rest of the space being occupied by air. The capacity of the condenser (neglecting edge effects) will be the same whether the solid plate rests against one of the two metal coatings or against the other, or occupies an intermediate position. Yet if, after the condenser is charged, the solid portion of the dielectric is moved across the gap, the value of the displacement at points within the gap will be completely changed. The question then may arise, have such local changes in a non-homogeneous dielectric a corresponding magnetic action? I do not think that there exists any experimental evidence on this point, unless the experiments of Prof. Röntgen (who rotated an ebonite disc in its own plane whilst it acted as the dielectric of a condenser), in the October number of Wiedemann's *Annalen*, are taken as establishing the existence of such an action. If his ebonite disc were homogeneous in itself it is difficult to see what the experiments prove.

The foregoing was written before I read Mr. O. Heaviside's letter, and the extract from Sir W. Thomson's, in *The Electrician* for November 9. Sir William asks us to consider the action of an electrified globe executing a simple-harmonic motion over a finite line. Here there are convexion currents and dis-

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placement currents, too. Is it to these jointly, or to either of them singly, that we are to look for the origin of the electromagnetic waves? (I notice, by the way, that on line 23 from the bottom of p. 23 Mr. Heaviside uses the word "displacement" in the kinematic and not in the electric Maxwellian sense.) The question, what is the velocity of propagation of vector-potential, is surely not more important than the question whether either, or both, of the actions discriminated above are concerned in the propagation of vector-potential. Will Prof. Lodge let us know how he views the matter?—Yours, &c.,

November 10, 1888. SILVANUS P. THOMPSON.

THE PIEZOMETER FOR DEEP-SEA TEMPERATURE SOUNDINGS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the important Paper read before the Society of Telegraph Engineers last week by Mr. W. Lant Carpenter, an allusion was made when dealing with instruments used to determine the temperature of the ocean, to the weak point in the ordinary thermometer—the fact that this instrument only registers maxima and minima temperatures, and need not necessarily record the temperature at the lowest depth to which it is lowered.

An instrument has been devised by Mr. J. G. Buchanan, F.R.S., called the Mercury Piezometer, which gets over this difficulty, and as it is but little known and has been very successfully used on recent Norwegian deep-sea expeditions, I venture to think that a brief description may be of interest.

The piezometer is nothing more than a Six thermometer with one end open. Its form is that of a ∩-shaped tube, having a large bulb at one end filled with mercury, while the other dips into a mercury cup which is so fitted that, while no mercury can escape, it is open to effects of pressure. The tube is filled with water, and contains a steel index, held in position by a horse-hair spring, just as in the registering thermometer.

The quantity of mercury is so much greater than that of water, and its compressibility so small, that the instrument is far more affected by temperature than by pressure; in fact, an increase of depth of 430 fathoms has the same effect as a fall of 1° C. in temperature. The necessary correction for pressure is obtained from the depth to which the instrument is lowered, as given by the sounding wire. It will be seen that so long as the temperature of the sea does not *increase* with the depth at a greater rate than 1°C. per 430 fathoms, the instrument will record the temperature at the greatest depth to which it is lowered correctly.

The only other instrument which pretends to do this is the capsizing thermometer of Negretti and Zambra, which has disadvantages when used at considerable depths.

A full description of the mercury piezometer is to be found in the *Journal* of the Chemical Society for October, 1878, and also in the "Challenger" Expedition report.—Yours, &c.,

November 12th, 1888. EDWARD STALLIBRASS.

MR. HAROLD BROWN ON ALTERNATING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I trust that, as the facts in the case come to your notice, you will modify your opinion on the dog-killing experiments. The large alternating-current installations in this country are a disgrace to electrical engineering; the insulation of the primary wires is absurdly poor, and, in consequence, fires and deaths are of frequent occurrence, as I shall soon have occasion to prove publicly. Tests have been made in a number of installations which show that on damp nights the leakage to ground is sufficient to kill any person touching either primary wire while standing on a wet place. The line work is in many cases carelessly done, and frequently the converters are placed indoors and within reaching distance of gas and water pipes. When you consider what a network of telephone and telegraph wires exists in the streets of every American city, you can get some idea of the danger to life which is thus caused, and which is intensified by the declarations of the alternating-current company employés that their systems are "absolutely safe" and "perfectly harmless," for samples of which I refer you to the reprints in the *Electrical World* of July 28. Against such misrepresentations the only effective answer was to use their own current and find the lowest voltage producing death, comparing it with the effects of the continuous current. This, with the kind assistance of Mr. A. E. Kennelly, I did, and the results proved that less than 200 volts of the alternating current was fatal, while, when the extra current caused by opening the circuit was eliminated, the continuous current was harmless at 1,560 volts, which was the highest then at command. I inclose a report of experiments under the auspices of Dr. Cyrus Edison and Dr. Chas. F. Roberts, of the New York Board of Health, and call your attention to the fact that Dr. Frederick Peterson is considered high authority on nerve structure, and Dr. Frank H. Ingram is an expert on diseases of the brain, while all the physicians present have had extensive experience in vivisection. Therefore, their opinion that "a dog has a higher vitality than a man, and that, therefore, a current which killed a dog would be fatal to a man under the same conditions," is entitled to careful consideration. I trust that in the spirit of fair-play for which the English people are famous you will give me space in your columns to endeavour to correct the impression that I wantonly sacrificed the lives of animals. The present tendency of electrical manufacturers and lighting companies in this country is toward higher and higher potentials; it is becoming common practice to run eighty to one hundred or more arc lights on a single circle circuit, and alternating currents of twenty-five hundred volts and more are being introduced. This upon wires whose insulation resistance is so low that heavy leakage can be detected even in dry weather. The list of fatal accidents in the United States already runs into the hundreds, nearly all of which are due to this criminal carelessness and false economy, and I intend to keep at work until legislation has placed all possible safeguards around the use of dangerous currents. A telegram from Pittsburg in yesterday's newspapers states that "George Westinghouse's Electric Company has been awarded the contract for a plant to light the City of London, England, to cost about $300,000." If this is true, you will be enabled to judge of the merits and "economy" of this type of apparatus, and I venture to say that you will not be overcome with enthusiasm. If it is untrue, you will be able to judge of the character of the people against whose reckless claims and careless methods I have been contending.—Yours, &c., HAROLD P. BROWN.

New York, November 1, 1888.

[We would refer our correspondent to a note in our editorial columns.—ED. *E.*]

The following is the extract enclosed with Mr. Brown's letter:—

At the School of Mines of Columbia College, experiments were lately undertaken, at the request of Harold P. Brown, electrical engineer, to determine the danger of alternating currents, by Dr. Cyrus Edson and Dr. Chas. F. Roberts, of the New York Board of Health. The first dog operated upon was a mongrel, weighing 61lb., strong and in good condition. His height was 24in.; length, from tip of nose to base of tail, 42in.; and resistance, from the right front leg to the left hind leg, 14,000 ohms. Connection was made by binding a piece of cotton waste saturated with water round the leg with No. 20 bare copper wire. The dog was placed in the cage and the alternating current applied by Dr. Roberts at 272·16 volts for five seconds; number of alternations, 288 per second. The dog was silent and motionless during the continuance of the current. He gave a few spasmodic gasps 31 seconds after current was first applied, and heart ceased beating 90 seconds after current was applied. The dog was immediately dissected by Dr. Roberts and Dr. Peterson, and section of sciatic and pneumogastric nerves, muscular fibres of diaphragm and lungs, placed under a microscope, and no changes in structure were observed. The second dog was a full-blooded Newfoundland, strong and in good condition, weighing 91lb.; length, from tip of nose to base of tail, 48in.; height, 25in.; resistance, 8,000 ohms. Connection was made in the same manner as above. Alternating current applied by Dr. Roberts at 340·5 volts electromotive force for five seconds. The dog was silent and motionless during continuance of current; howled and gasped for eight seconds after circuit was opened, but in the opinion of physicians present this was purely mechanical action, as the dog was unconscious from the instant the current first reached him. Heart stopped beating in two minutes and fifty seconds after current was first applied. The third dog was a half-breed setter and Newfoundland, weighing 53lb., 42in. long from tip of nose to base of tail, and 24in. high; resistance, 30,000 ohms. Connections were made in the same way as before. Dr. Roberts applied the alternating current at 220 volts for five seconds; the result was not fatal at four minutes afterwards. Mr. Porter, superintendent of machinery of Columbia College, then suggested that as the dog was rigid and motionless during the continuance of the shock, it would be impossible for a man in the same conditions to utter a sound or to break the contact in five seconds. Dr. Edson then determined to administer the current at the same number of

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volts for 30 seconds on this account and on account of the high resistance of this subject. This was done, and during the period of the 30 seconds the voltage rose to 234 volts. The dog died instantly without sound or struggle. The resistance after death was found to be 2,800 ohms. All of the physicians present expressed the opinion that a dog had a higher vitality than a man, and that, therefore, a current which killed a dog would be fatal to a man under the same conditions. It was their opinion that all of these deaths were painless, as the nerves were probably destroyed in less time than that required to transmit the impression to the brain of the subject.

Dr. Edson invited Elihu Thomson, of Boston, and Dr. Otto A. Moses to be present with measuring instruments to check up the voltage, &c., but neither of these gentlemen put in an appearance or responded. Approved by Dr. Cyrus Edson, of the Board of Health; Dr. Chas. F. Roberts, Assistant Professor of Physiology, Bellevue Hospital Medical College; Dr. Frederick Peterson, Dr. Frank H. Ingram, Dr. H. A. Haubold, Mr. John Murray Mitchell, Professors C. E. Colby and E. H. Laudy, of Columbia College; Captain E. L. Zalinski, U.S.A.; and Dr. Schuyler S. Wheeler, Electrician of the Board of Electrical Control.

GLOBE LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think the following account of what appears to be an instance of globular discharge may be of interest:—

On the 18th of last April a line foreman, formerly in the Royal Engineers, and whose veracity does not admit of doubt, was standing in the terminal room of the United Telephone Company's exchange at Westminster, the window facing north being wide open, when he saw an ordinary flash of lightning; this was accompanied by a crash of thunder, almost explosive in its violence and lasting for several seconds. Immediately the sound had ceased he saw what he describes as a fiery ball, about an inch in diameter, resembling a mass of white-hot iron enter the window with a fizzing noise—like a fuse burning or a rocket rushing through the air—and leaving behind it a fiery trail; it struck against the terminal board with a thud, as though the ball were of some plastic material, and then bounded back again out of the window. A slight odour of sulphurous nature was noticed. No mark was left on the board, but about thirty indicators were found to be damaged in the exchange.—Yours, &c.,

C. H. WORDINGHAM, A.K.C., A.S.T.E.

[This seems to be one of the most remarkable cases on record. Can our correspondent describe the nature of the damage sustained by the indicators? Were the coils burnt or fused as from a powerful current, or were the metal frames damaged?—ED. *E.*]

TELEGRAPHY WITHOUT WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The extent of the field in which return currents may be "picked up" by intermediate conductors, in the manner shown by Mr. Willoughby Smith, is a subject deserving more research than has hitherto been given to it. Mr. Swinton, in his letter of last week, gives his experience in this direction, and it is by no means an uncommon one to those engaged in working telephone circuits in large towns; in fact, such currents have, in some instances, at times been of sufficient strength to work the indicators in exchanges. The principal offenders in this respect are the printing telegraph and the Wheatstone automatic circuits, the latter, owing to the rapidity of its makes and breaks and current reversals, being the most noisy. One of the most remarkable instances that I have experienced was on a circuit inside a building in London. The line, which was not more than 40 yards long, was an insulated copper wire, and ran between two rooms on the fourth floor, one in the front and the other in the back of the building. The gas pipes were used as the return. On this circuit the humming of the Wheatstone automatic instrument could be distinctly heard in a telephone, and the periods when the machine was running empty or with messages clearly distinguished. No telegraph wires were anywhere near overhead the nearest underground ones running parallel to the direction of the line were about 200 yards away, and some were probably under the street in which the building stood, and would then be at right angles to the direction of the line. The only explanation I could arrive at was that as the gas supply for the front rooms of the building was brought by a pipe in the front portion, and that for the back room by a pipe in the back, these two pipes may have earthed in two different points, and so picked up a current. The fact that the whole supply of the building was from one meter in the front would appear to be against this solution to some extent; but if this were the correct one it shows how remarkably easily these currents may be "picked up."

In those cases where the noise from the picked-up current prevents the proper working of a telephone, or if the current is of sufficient strength to operate the indicator, the trouble has generally been overcome by obtaining a new earth for the telephone, as far from that of the offending telegraph instrument as possible. Sometimes, when several telephones have earthed near a telegraph earth, it has been necessary to run one low-resistance wire from some good earth, or from the exchange, and use this for the earth of all these telephones. In America, according to a Paper read before the Telephone Congress, the same difficulty has been found and cured in a similar manner, only in their case electric railway currents seem to have been the chief cause of the trouble.

I am afraid that the term induction is often used in this country to cover a multitude of sins. The American phrase cross-talk is better, as it covers induction proper, leakage and picked up currents.—Yours, &c.,

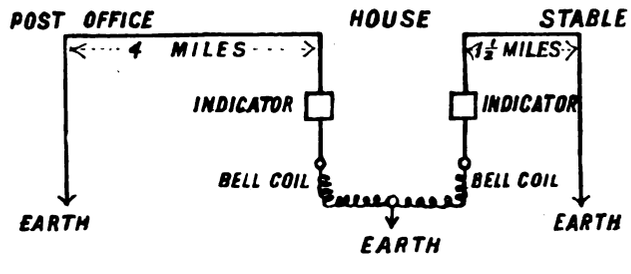
F. B. O. HAWES.

East Ferry-road Engineering Works,
14th November, 1888.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to this subject the following facts may be of interest to your readers:—

Some ten or twelve years ago, when living in Northamptonshire, I had an A B C Wheatstone instrument in my house, in communication with the Stamford post office, distant about four miles. I had also a line to some stables about one and a-half mile in an almost diametrically opposite direction. The two lines met in the house and were conducted, first through indicators and then through a specially constructed bell, with separate coils for each circuit to earth. The earth was made as good as possible, nevertheless it was frequently found that on one station endeavouring to call me up enough current returned through the other line to work the indicator and bell at far end, so that both indicators would drop, and the man at the stables, say, thinking I was calling from the house, would endeavour to reply; and it was not until I inserted a very considerable resistance in each line that I could stop this effect. I cannot at the time recall what the necessary resistance was, but I believe I have the coils somewhere, and if you think it would be of interest I will endeavour to ascertain their resistances. The following rough sketch may help explanation:—



Of course in using the arrangement the line in use was switched off the indicator on to an A B C instrument, one instrument thus serving for either line.—Yours, &c.,

R. H. C. NEVILE.

Wellingore Hall, Grantham, November 12, 1888.

[Does not this merely go to show that the "earth" was bad at the house, or at any rate that it had a much higher resistance than that at either end of the line?—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have much pleasure in replying to Mr. Charles Bright's inquiries on the subject of my experiments for telegraphing without wires. The boat employed on this occasion was a

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wooden one, but it would have been much better for my purpose had it been of metal, for then I should have used it in the stead of one of the accumulating plates, as the larger the surface of these plates the better the results obtained.

With regard to the position of the plates, of course there would be a difference, for as I say in my letter, when speaking of the tank experiments, "These two wires, so fixed and immersed, were moved in each section, until the position of maximum potential was obtained." But there are many ways of obviating this difficulty in a shifting body.

In my experiment from the beach the plates are drawn as hanging perpendicularly from the boat, but considering the force of the current and the boisterous state of the sea, which caused the boat to be very unsteady, it would be difficult to say what was really the position of the accumulating plates.

Electrical signals were sent from the shore to the boat, and also from the boat to the shore, the rapidity and correctness with which they were received more than realising my expectations.—Yours, &c., WILLOUGHBY SMITH.

November 12, 1888.

MR. CAMPBELL SWINTON'S "PHENOMENON."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The disturbance upon a wire between 75, Queen Victoria-street and 59, Knightrider-street, mentioned in Mr. Swinton's letter in your last issue, is, I think, more likely to be due to induction from a wire of ours which crosses it than to the cause mentioned. Our signals upon that wire resemble those of the Wheatstone, and are sometimes audible in telephones.—Yours, &c., F. HIGGINS.

17 and 18, Cornhill, E.C., November 9, 1888.

TELEPHONE CALL OFFICES IN LONDON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In giving 1880 as the date of the first London Call Office, Mr. Munro is basing on information that *must* be inaccurate. It is a matter of common knowledge in telephone circles that there was no call office in London prior to 1883. In order to make good his assertion Mr. Munro should give the exact addresses of the call offices he refers to, and mention the date of the first list of subscribers issued by the United Telephone Company in which the opening of a call office is announced. If he will look into the matter for himself he will find that 1883 is the real date.—Yours, &c., A. S. T. E. and E.

November 12, 1888.

REWARDS FOR MERITORIOUS DISCOVERIES AND INVENTIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Committee on Science and the Arts of the Franklin Institute, of the State of Pennsylvania, respectfully requests that you will cause to be made known to the readers of your influential journal the fact that the committee is empowered to award, or to recommend the award of, certain medals for meritorious discoveries and inventions which tend to the progress of the arts and manufactures.

These medals are:—

1. THE ELLIOTT CRESSON MEDAL (GOLD).—This medal was founded by the legacy of Elliott Cresson, of Philadelphia, and conveyed to trustees of the Franklin Institute. By the Act of the Institution, May 17, 1849, the Committee on Science and the Arts was designated and empowered to award this medal, and the committee decided to grant it, after proper investigation and report by sub-committee, either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill, or perfection in workmanship.

2. THE JOHN SCOTT LEGACY PREMIUM AND MEDAL (20 DOLLARS AND A MEDAL OF COPPER).—The John Scott Legacy Premium and Medal was founded in 1816 by John Scott, a merchant of Edinburgh, Scotland, who bequeathed to the City of Philadelphia a considerable sum of money, the interest of which should be devoted to rewarding ingenious men and women who make useful inventions. The premium is not to exceed 20 dollars, and the medal is to be of copper, and inscribed "*To the most deserving.*"

The control of the Scott Legacy Premium and Medal (by Act of 1869) was transferred to the Board of Directors of City Trusts, and referred by the Board to its Committee on Minor Trusts, and that committee resolved that it would receive favourably the name of any person whom the Franklin Institute may from time to time report to the Committee on Minor Trusts as worthy to receive the Scott Legacy Premium and Medal.

The Franklin Institute, by resolution in 1882, accepted the above-named action of the Committee on Minor Trusts, and referred the duty of making such recommendations to the Committee on Science and the Arts. The committee determined that the recommendation for such reward shall be made on the favourable report of a sub-committee which shall be appointed to examine the invention or discovery.

The committee requests your co-operation in facilitating the making of the aforesaid award for meritorious discoveries and inventions by bringing the facts herein set forth to the knowledge of your readers.

Upon request therefore, from interested parties, made to the Secretary of the Franklin Instititute, full information will be sent respecting the manner of making application for the investigation of inventions and discoveries; furthermore, the Committee on Science and Arts will receive and give respectful consideration to reports upon discoveries and inventions, which may be sent to it with the view of receiving one or the other of the awards herein-named, and full directions as to the manner and form in which such communications should properly be made will be sent on application.—By the Committee's order,

WM. H. WAHL, Secretary.

The Franklin Institute of the State of Pennsylvania
for the Promotion of the Mechanic Arts,
Philadelphia, October 1st, 1888.

ELECTRIC LIGHT AT THE BANK OF ENGLAND.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As we hear that a report has been circulated in the City with reference to the above installation which may be prejudicial to electric lighting interests, we shall be glad if you can find space for a short explanation of the facts.

We are pleased to say there is not the slightest foundation for the statement that the Bank of England are discontinuing the use of the electric light, in fact we are at this moment engaged in fixing two large gas engines to supplement the 50 horse-power steam engine, which has run without a hitch of any kind from the moment it was started. Possibly the rumour has originated through the temporary cessation of the light in the drawing office, where it had been found necessary to rearrange the early installation put down by another company some years ago. But we shall have this ready for use again shortly, and in the meantime we are pleased to notice that the short compulsory return to gas is by no means appreciated by the bank staff.—Yours, &c.,

DRAKE AND GORHAM, Electrical Engineers.

2, Princes-mansions, Victoria-street, S.W.

BOOKS, &c., RECEIVED.

"The Theory and Practice of Absolute Measurements in Electricity and Magnetism." By ANDREW GRAY, M.A., F.R.S.E. Vol. I. (London: Macmillan and Co.)

"Compound Winding Dynamos." By S. Alfred Varley.

"Report of the Special Public Lighting Committee of the Detroit Board of Aldermen." Adopted July 17, 1888. (Detroit).

"The Ries Electric Railway System." (Baltimore).

"The Elements of Electric Lighting." By Philip Atkinson, A.M., Ph.D. (New York: D. van Nostrand.)

"The *Journal* of the Franklin Institute. Vol. CXXVI., No. 755. (Philadelphia.)

"The Life of Sir William Siemens, F.R.S., D.C.L., LL.D., M.I.C.E." By WILLIAM POLE, F.R.S. (London: John Murray.)

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SOME NEW INSTRUMENTS BY THE CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY.

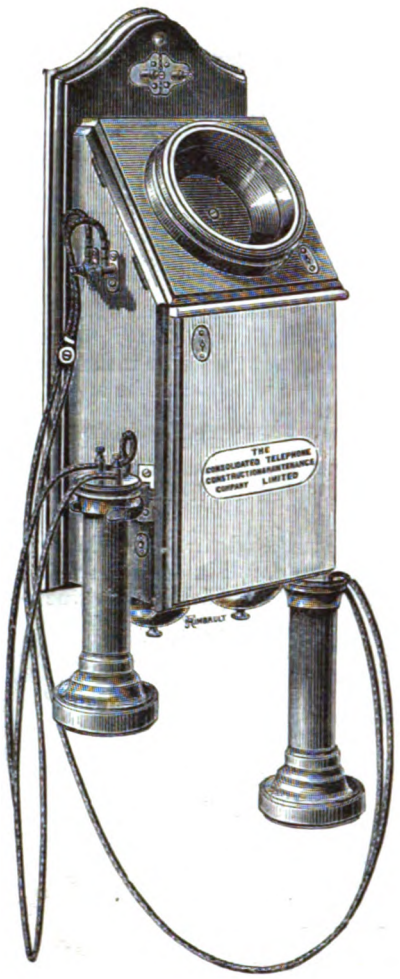

FIG. 1.

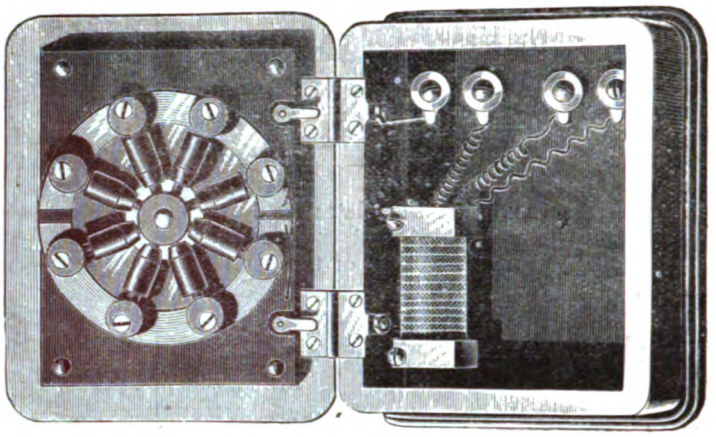

FIG. 2.

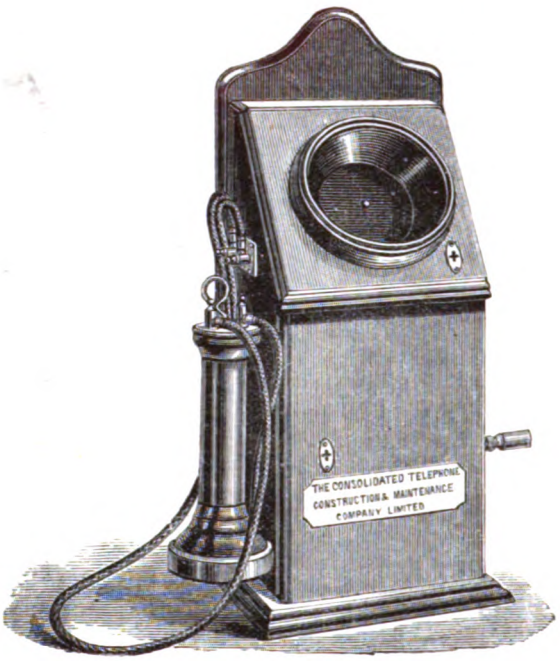

FIG. 3.

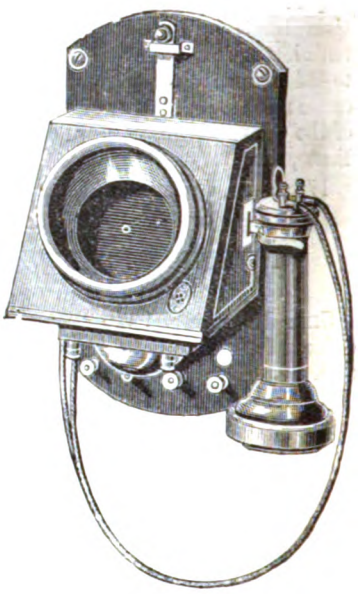

FIG. 4.

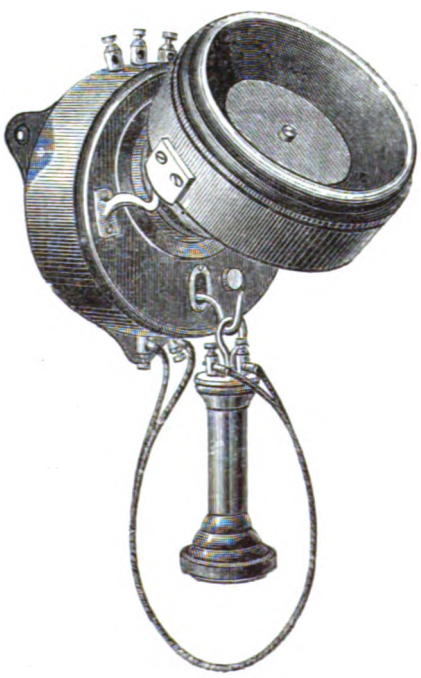

FIG. 5.

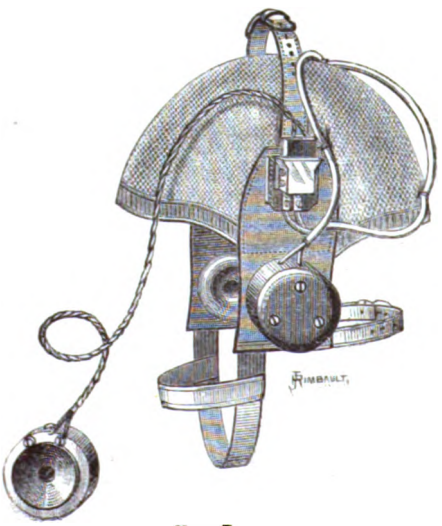

FIG. 7.

FIG. 9.

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As most of our readers will be aware, the Telephone Construction and Maintenance Company, whilst manufacturing the whole of the instruments required by the United Telephone and its subsidiary companies, and also by the Postal Telegraph Department, are precluded from the sale of their instruments in the open market within the limits of the United Kingdom. An outlet for their enterprise still exists, however, in the manufacture and supply of telephone *matériel* of all descriptions for the remainder of the civilised world, and in consequence a very large variety of "combination sets" of transmitting, receiving, and call instruments has been designed to meet the varying needs of their customers. Some of the latest of these we shall briefly describe.

The "Consolidated Magneto Telephone," while being considered a first-class instrument for exchange purposes, is described as being specially suited for use in remote districts, where non-liability to get out of order is a first consideration. We can hardly doubt that this requirement has been adequately fulfilled in the type before us.

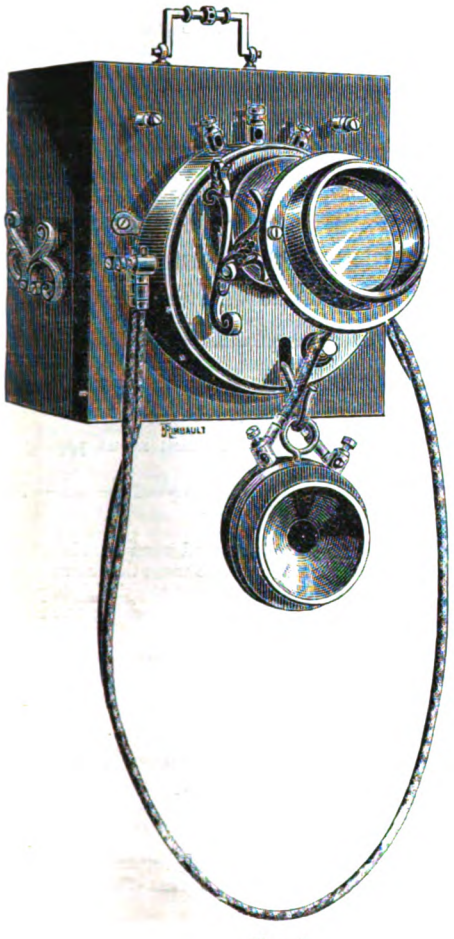

Fig. 6.

The apparatus (Fig. 1) consists of a combination of parts which in the experience of the company have been found most effective in practical use. The transmitter is a modified form of the Crossley type, in which a number of carbon pencils radiate from a central block mounted on a diaphragm, the outer ends of the pencils being held by separate blocks of carbon, which are fastened directly to the framework of the instrument, as shown in Fig. 2. This arrangement is peculiarly sensitive, and requires no adjustment of any kind. The armature of the magneto call transmitter is driven by tooth-geared wheels, which for this purpose are more reliable than friction gear. The receiver is of the ordinary Bell type. Fig. 3 illustrates a set of the same general description, but adapted for standing on a desk or table. The call bell is at the back. Fig. 4 illustrates a form which is specially designed for the sake of simplicity and cheapness. Three Leclanché cells, not shown in the figure, are required for the transmitter and call bell. Fig. 5 is a still less expensive type, and is intended chiefly for use in large establishments or for private lines. Fig. 6 is a neat portable arrangement known as the "FitzGerald" combination. It is particularly adapted for offices that require to be connected up from floor to floor, and the company have invented and patented a very cheap form of switchboard to be used in connection with this instrument. Fig. 7 illustrates a complete set of transmitter and receivers intended to be worn by a diver under his helmet. The receivers cover each ear, whilst the transmitter is fitted in a recess near the mouth. Fig. 8 illustrates the arrangement at the shore end of the diver's telephone, at which a battery transmitter is employed. A large number of these sets have been supplied to the Admiralty, and have been used with great success Fig. 9 represents the "Operator's telephone," as used by the General Post Office in some of their exchanges. It consists of a transmitter (*a*), receiver (*b*), and closing key (*c*) contained in the handle by which it is held. Fig. 10 represents an "Operator's receiver," which is worn strapped upon the head. This form is largely used in Lisbon by subscribers to the exchanges who wish to hear the opera from their own houses.

Numerous other forms are made by the Consolidated Telephone Company, embodying the Blake and Hunnings transmitter and the Gower-Bell receiver; but most of these combinations, except for special purposes, are of less value than those described.

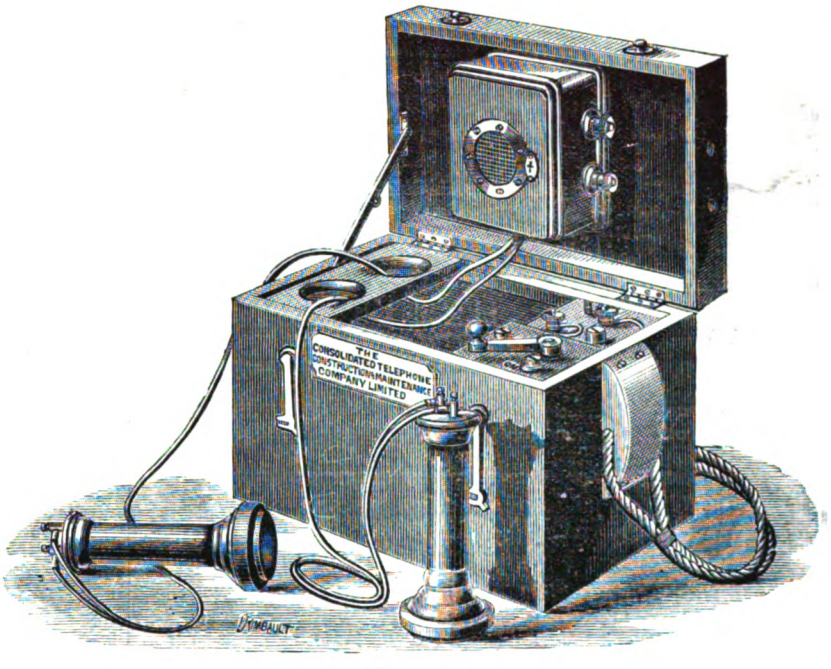

Fig. 8.

Fig. 10.

COMPANIES' MEETINGS.

West India and Panama Telegraph Company (Limited).

The twenty-third ordinary general meeting of this Company was held at Winchester House, Old Broad-street, on the 14th inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the notice calling the meeting and the minutes of the last general meeting, which were confirmed and signed by the Chairman as correct. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, our meeting to-day is marked by one circumstance which makes it of a somewhat exceptional character. It is the first time in the twenty years since the Company has been in existence that we have ever met with all of our cables in working

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order. You see by the map that there are a great many separate sections. They are not all ours, but the map shows what a number of sections we have, and we are very subject in that unpropitious field, the Caribbean Sea, to interruptions. I do not wish you to draw too favourable an augury from this absence of interruptions. Though I believe the system is in a stronger and better condition than it ever was in before, still, knowing what I do of those waters, I do not wish to lead you to suppose that the halcyon days of freedom of disasters which are so costly to us are likely to arise. In fact, I may tell you that since this report was written we have had one interruption. It was, fortunately, smartly repaired by our maintenance ship, "The Duchess of Marlborough," and it was of very short duration. I merely mention that to show you that even while we are now speaking the satisfactory condition of things to which I am alluding may be modified. With regard to the accounts, it is satisfactory to note that there is a small increase in the traffic revenue of the Company. On the debit side of the accounts there is very little indeed to remark upon. There is a slight increase in the salaries and wages—a fact accounted for by the promotions that we think it just and politic from time to time to give to the *employés* of the Company whose experience and length of service warrant a little encouragement. A hopeless service would be a bad service, and I think that the few pounds that we lay out in encouraging the staff from time to time and we have to do it with rather close hands, I am sorry to say) is a good policy for the Company. The chief increase in the expenditure side of the accounts is owing to expenses for repairs of cables, which amounted to £2,241 in excess of those of the corresponding period of 1887. That increase is entirely accounted for by the extra length of cable we have been obliged to put in in course of the sundry repairs executed during the half year, but that expenditure is not without its compensating influence upon the accounts, because it goes to diminish the contribution we should otherwise have to make to the reserve fund. Of course the reserve of a telegraph company is principally a depreciation fund—a fund built up for the renewal of the cables from time to time, as they may fail, and if at any one time we may put, say, 100 miles of new cable into the system, that goes towards fulfilling the purposes of a reserve fund, and exonerates us from putting the whole sum which we should otherwise have to do to the reserve fund to keep up the calculated extent of depreciation. With regard to the reserve fund, the policy of forming it at all and of keeping it up has been very often seriously criticised in this room; but I think I may claim that the present market position of the shares of the Company, in comparison with what it was in former days, is very much owing to the existence of that reserve fund which we have, in spite of a good deal of opposition, never ceased to maintain, and I hope this meeting will endorse that policy and encourage the Board to keep up the mainstay of our system and the basis of what little prosperity we may have. Our report this time is, perhaps, the shortest we have ever laid before you; but I should be, perhaps, not properly filling my place here if I led you to suppose that that fact was attributable to there being no clouds on our horizon in the West Indies. There is, I am sorry to say, a growing feeling among the Governments of that region against the continuance of our subsidies. They are now voted only annually. At first these were voted for ten years. Those subsidies then expired, and, in many cases, the Councils and Chambers of the various Governments have taken to voting an annual subsidy only. That is an unfortunate policy, both for them and for us—for us because it gives us no security of tenure, and that absence of security of tenure tends to restrict our operations in carrying out the measures which would be to the benefit of the telegraph service of the country. For instance, there is no encouragement for us to duplicate a weak cable when the subsidies are only the matter of an annual vote. There is also another cause for anxiety about our position in the West Indies; that is, the renewal of the French competition. Since we last met a new cable has been laid by a French Company from Venezuela to San Domingo and Santiago de Cuba. At present that Company does not interfere very seriously with our traffic, and we should not oppose them did we not know that their statutes their articles of association—lay down that one of the objects of the Company is to extend and develop French telegraphs, and we are not without some anticipation that they may eventually make extensions into our territory. I believe the ground they occupy now is in contravention of their own concession, and I am quite sure it is in contravention of our Spanish concession, and we have therefore felt it our duty in protection of your interests to call the attention of the Spanish Government to the subject. We do not want to act the part of the dog-in-the-manger, but we object very strongly to their going to any of our stations. Not one of those stations can afford to support another company, and therefore competition would not only be disastrous to us and to the colonies but also to the competing company. I now beg to move the following resolution:—

"That the Directors' report and accounts to the 30th June, 1888, submitted to this meeting, be and the same are hereby received and adopted, and that, as recommended by the Board, a payment of 12s. per share on account of arrears of dividend on the First Preference Shares be and the same is hereby declared."

Mr. FORD seconded the motion.

Mr. ODELL asked how it was that there had been an increase in the item of insurance of ships.

The CHAIRMAN: There is no increase. It may be the incidence of the insurance that became due just before the accounts were closed, but there is no increase in the insurance charges for the year.

Mr. ODELL: Last year the amount was £522, and this year it was £1,422, so there must be an increase.

The CHAIRMAN: If you take the corresponding account you will find that the amount is the same. The insurances are payable in April. It is merely the incidence of the payment. There is no increase.

Mr. ODELL said that one of their investments was £5,000 in Three and a-Half per Cent. Debenture Bonds of the Oude and Rohilkund Railway, and he stated that there was no such stock in the share list.

The CHAIRMAN: It is not actually quoted; but it was the very best thing that we could buy at the time. It is going to be paid off, I believe.

Mr. FORD: I believe you can get more for it now than it cost you. I am told that there is a daily market for the bonds.

Mr. ODELL said he had carefully calculated the present value of their investments, and found that at the lowest quotations there was a profit of over £11,000. The only investment that showed any loss was the East and West India Debenture Stock, and the Directors had increased their holding in the past half year in that stock.

The CHAIRMAN: We have rounded off the amount of that investment. That stock is very low, and we are told and believe that it will come out right.

Mr. ODELL said that the bonds only stood at 80 now. He thought, seeing that that the arrears of dividend were now reduced to only £44,000, that that amount ought to be paid off out of the investments, and then a dividend of 2 per cent. could be paid on the Ordinary shares and £7,000 could be added to the reserve fund. He had been a shareholder for sixteen years, and during that time he had received only two small dividends.—

A SHAREHOLDER asked whether any communication had taken place between the Company and the Colonial Governments on the subject of their limiting the period for which the subsidies were now paid. Had the Governments given any reason for their action? Was it due to any interruptions of the cable?

The CHAIRMAN: We are in frequent communication with those Governments. It is not owing to interruptions, but in consequence of the idea that prevails that someone else is going to take a cable to their islands, and therefore they do not wish to be bound for any length of time to us. In reply to another question, the Chairman added: The total subsidies received by the Company amount to £24,000 a year if they are all paid, but they make deductions for interruptions and other things.

Mr. WHEELER observed that at the last meeting reference was made to a Company working between Trinidad and the main land, and he believed the Chairman said on that occasion that the Directors were in communication with the Government on the subject.

The CHAIRMAN: I referred to the duplication of the Barbadoes and Demerara cable.

Mr. WHEELER inquired what the result of the communication had been?

The CHAIRMAN: Nothing further has occurred.

Mr. ODELL said he would like a reply to his remark about paying off the arrears of dividend out of the reserve fund.

The CHAIRMAN: It is a very satisfactory account altogether, but you want us to take this money out of the reserve fund.

Mr. ODELL: Well, and why not do so?

The CHAIRMAN: The reserve fund is calculated upon a certain basis to meet the depreciation of our cables, and before we meet the depreciation which occurs in our cables year by year we have not any divisible profit. The reserve fund is for depreciation, and not for division among the shareholders.

Mr. FORD observed that if they were to adopt Mr. Odell's suggestion they would next time have to use the whole of the profit to make up the amount paid away as advocated by Mr. Odell. It was the duty of the Directors to keep up the reserve fund.

Mr. WM. ANDREWS: And the reserve fund must grow as depreciation grows, unless you can stop the depreciation that goes on at the bottom of the sea.

The CHAIRMAN put the motion, which was carried.

On the motion of Mr. NICHOLSON, seconded by Mr. ODELL, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN: I am very much obliged to you, and so are the Board, for your vote of thanks. We shall always do what we can to promote the interests of the Company.

The proceedings then terminated.

The Australasian Electric Light, Power and Storage Company (Limited).

The sixth ordinary general meeting of this Company was held at the Company's office, 41, Coleman-street, on Monday last, under the presidency of Mr. B. H. Van Tromp.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN said: In rising to move the adoption of the report and accounts, I think it will only be necessary to trouble you with a very few observations. You will remember on the last occasion that I told you we had made new arrangements with respect to the expenses in Australia and London. Those new arrangements only came into operation for two months of the year 1887, up to which date these accounts are brought down, and, therefore, it was not apprehended that we should derive much benefit from the changes made, in so far as last year's working was concerned; the benefit will accrue in future years, and has already accrued in the current year. In looking at the accounts now submitted you will find that there has been a loss on the year's working down to the 31st December last. I think it was pretty well understood at the meeting held in October last year that there would be a loss; but I told you then that we had great hopes in the future that we should so keep down expenses as to prevent the possibility of a loss, and I venture to hope that when we meet you this time next year we shall be able to bring

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before you such a statement of accounts and such a statement of the progress made in Australia as will give you renewed confidence in your Board, and that you will continue to believe, as I feel sure you do at this moment, that we are perfectly honest in our endeavours to do the best we can for this Company. You will remember that at the close of my speech last year, when you were kind enough to pass a resolution of confidence in the Board, I gave a pledge in the name of the Directors that no effort should be wanting on their part to bring this Company eventually into a dividend-paying condition. Our efforts this year have been mainly directed to securing a contract in Melbourne for the lighting of the Exhibition there—a contract larger than has ever been entered into, and an enterprise more important as regards any exhibition of a temporary character in the whole world. When I tell you that this arrangement was carried out solely by means of cablegrams to Australia, requiring daily watchfulness, constant meetings, and the utmost care and attention in giving directions in Australia, so as to secure the contract without the possibility of loss, I think you will see that we have been working hard to promote your interests. Captain Rowan, our able manager in Australia, made supreme efforts to get this contract, and he was successful, being most untiring in his exertions on your behalf, and showing an amount of ability which scarcely anyone on this side had up to that time given him credit for. That contract was secured against a very large number of competitors, American, German and Hungarian. There were others, too, who tried to obtain it, but we succeeded in getting the contract, and, as far as our present advices will enable us to say, we on this side expect to receive a net profit of at least £4,500 or £5,000 out of that contract alone. I think this is something that should be mentioned with a degree of satisfaction by the Board, and I do hope that the shareholders will give us credit for having taken immense trouble and devoted a great deal of time and attention to the securing of such a work. In addition to the profit that we are going to make from it it has given us a high position in Australia, and it has given electric lighting a great start there. The commissioners to the Exhibition have stated that the whole of the work has been carried through to their entire satisfaction, and that the lighting has succeeded in every respect, and we have not received on this side a word of complaint in respect to it. It is a great satisfaction to us to tell you we believe that no penalty will be incurred in connection with the contract. We were ready at the moment, though we had only two months in which to prepare in this country and send out an enormous plant. You may possibly wish to know how that was done without our having any money. From the last accounts you will see that the Company possessed in uncalled capital about £11,000 or £12,000, upon which there was a loan of £5,000, so that all the credit we had was about £6,500, and if we had called up that it would have exhausted all the Company's money. The Board thought it better to act on the advice of a shareholder at the last meeting, who implored us not to make the final call. The Directors, instead of that, gave their personal guarantee, and also entered into a very satisfactory arrangement with the Anglo-American Brush Company to supply the plant. I do not propose to refer at any length to the accounts of 1887, which are before you. You can, as men of business, see where the loss has been; but I will ask your special attention to the items which have been put in comparative columns, and you will see that, except in the item of cables and telegrams, there has been a saving under every heading. But for our care in that respect, the loss made in 1887 would have been very much greater. I told you last year that we were in a sort of transition state in Melbourne. We were having a very voluminous correspondence with Captain Rowan and agents in the colony, and we wanted to reorganise the whole thing. But at this distance from Australia, it is very difficult to carry out any arrangements through correspondence and cablegrams. Everything, therefore, apparently remained at a standstill. In our negotiations with the agents, and in our correspondence with Captain Rowan, the business of the Company over there was to some extent lost sight of. Hence it was that the profits were not so large and the sales were not so great. On the other hand, we have succeeded in doing what I have mentioned, and I believe that the adoption of the electric light in Australia and the whole of the Colonies, at the Cape and in India, is purely a matter of the future. We are the holders of the field there. We have the greater portion of the Cape of Good Hope, India, Queensland and New Zealand. We have all that before us, and I can only tell you this, that there is only one thing wanting to make us a tremendous success in all these places, and that is money. I pointed out last year that before we began work three-fourths of our capital had disappeared, invested in patents, &c. This is the seventh year of the Company's existence, this being our sixth annual meeting, and we have, therefore, served our apprenticeship. We have our indentures in our pockets, and we intend to do something with them in the future, with your assistance. It is my belief, and the opinion is shared by the whole Board, that if we could see our way, by issuing Preference shares with a dividend of 5, 6, or 7 per cent., or whatever you might agree upon, to obtain £15,000 or £20,000, which could be devoted exclusively to the purpose of opening a magnificent lighting station in some large city like Bombay or Calcutta, or at Sydney, Adelaide, and other large towns of Australasia, we should make a very handsome profit on that amount. If we gave our pledge that that money should not be used except for establishing a large lighting station having good prospects of success, I believe that you who are present and those who might be appealed to on a future occasion would give us their hearty support. Upon that matter, however, I will not say any more. There are others here who may say something about it. We court the fullest discussion as to the affairs of the Company. I have always looked upon Directors as the servants of the shareholders, and not as their masters, as some Directors consider themselves. We want your advice. We have a very good thing in this Company, and I believe there is a great future for it in connection with our interests in the Australian Electric Company, which is established in Melbourne. You may remember in the earlier part of our history the establishment of a company in the city of Melbourne, in which we hold an interest representing more than a third of the capital. That company are carrying on a considerable business. Their lighting is extending very considerably. They have made new contracts with large wholesale houses for lighting, and are spreading their work throughout the whole of the city. But they are doing more. They are trying to bring into existence a new body of gentlemen, who will find plenty of money in order to bring this thing thoroughly into effect in the city of Melbourne. I am informed at this moment that negotiations are going on, under which the Australian Electric Company will be, I will not say absorbed, but joined to a larger undertaking with ample resources. You may depend upon it we shall try and get a good *quid pro quo* for our shares in that company. The lighting of the Exhibition, having been such a grand success, has excited the attention of everyone on that side of the world to the importance of the electric light, and we do firmly believe that if you can only wait a year or two more you will be rewarded. If you let us go on for a year or two more I am sanguine that we shall be successful. I think there is nothing that commands success so much as the feeling that you must have success and that you deserve it. In this case we deserve success. The shareholders have shown the utmost patience, and we still look to them for their support, consideration, and assistance. Throughout the whole world there is now a great movement for the electric light. The Edison Company, I see by a paragraph in the newspapers, contemplate increasing their capital. They are putting up a new station in the capital of Berlin, and the cry is still for more light. In the city of Berlin they appear to be determined to have no street lighted except by the electric light, and the day is coming when London, and, indeed, every city in the world, will make use of the electric light, unless a better one can be found. I may say with regard to those dreadful Whitechapel murders, that it is stated that every arc lamp in the streets of New York is equal to one policeman. That is what is said there. As time goes on and the electric light is more easily understood, there will be no diffi-

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BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
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WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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culty in every citizen of London having the light put into his house, and I venture to predict that there will be no increase in the cost of lighting by electricity as compared with lighting by gas or candle. I am a director of a large hotel, in which we have recently installed the electric light, and we are going to keep it, as it gives immense satisfaction to visitors, and there is little additional cost.

A SHAREHOLDER: Is it your own installation.

The CHAIRMAN: Not at present. We have a contract; but by next year we hope to make it our own installation. I need not dwell upon the advantages of the electric light, as they are so well known and recognised. I can only point out the immense safety of the light. Look at the number of deaths that occur through the use of lamps, and remember that the moment the electric light ceases to burn, or the moment the air gets to it, the light goes out.

A SHAREHOLDER inquired what was the hotel to which the Chairman had referred.

The CHAIRMAN: The Grand Hotel, Brighton. Last year I was at the Schweitzerhof Hotel at Lucerne. There, in the bed rooms, lavatories, and other places open to visitors and the public, the electric light was in use. You turned it on as you entered a room and turned it out when you went to bed, and the proprietor told me that in no case was any advantage taken by the visitors by burning it all night. I believe, myself, that in Australia above all places, being a new country, where gas is dear and money plentiful, and where land is rising so enormously in value, there is a great future for the electric light. If anything in this world should revive the drooping energies of a body of shareholders it is electricity. With your assistance I believe we shall be in a stronger position next year. I might have gone into a variety of details on a dozen different matters, but you are all men of business and as good judges as I am of what is best to be done. I invite you to ask any questions, to sit in council, as it were, with us, and to give us your advice. I would ask the shareholders to consider this point—whether it would not be advisable for two or three of them, either large or small, to consult with us on the affairs of the Company, and to advise with us, first, as to the desirability of raising some new capital; secondly, the mode in which it should be accomplished; and, thirdly, to what purpose that money, when raised, should be devoted. If they would do that a circular might be issued calling the attention of the shareholders to the matter. I feel that we are like men going on board a ship who have eaten their provisions. We have such a small sum of money in hand that we are hampered in every direction. We are afraid to go boldly into any great thing, and it was with considerable fear at first that the Board ventured on the contract at Melbourne (cheers). I will now conclude by moving—

"*That the report of the Directors and the accounts appended thereto be received and adopted.*"

Mr. GUESDON seconded the motion. He regarded the Directors not as the servants of the shareholders, as the Chairman had said, but as their managing partners. With respect to electricity they might reasonably look forward with confidence that it must be the light of the future. Gas had an immense struggle before it superseded oil, and for many years gas was considered the most perfect light we could have. Now, however, there was no doubt that electricity would supersede gas, and he said so notwithstanding the fact that he was interested in gas as a shareholder. He strongly urged the shareholders to place the Company in a fair position to fight the battle that was before it. They were now working at a disadvantage, and they could not achieve success without more money. He should certainly be ready to take his share in any issue of Preference shares which the Directors might decide upon. He was an Englishman, and he did not like to see them cut out by others, and especially by foreigners. It must be a matter of great regret to Englishmen to see so much business which ought to be in their own hands in the hands of foreigners. In the case of the Company the shareholders must exercise a little patience, and certainly more money must be provided, and he urged the shareholders to respond to any appeal that the Directors might make to them in order that the Company might have a fair chance of success.

Mr. MORRISON agreed with the Chairman that the electric light was in its infancy. He (the speaker) had just returned from the United States, where the development of the electric light was something extraordinary. He saw no reason why it should not progress in a similar way in this country. He agreed that electricity could be supplied as cheaply as gas, particularly with a large centre of supply. He thought the meeting was held unduly late after the making up of the accounts, and he urged that in future it should be held sooner. He congratulated the Directors on the appointment of Messrs. Gibbs, Bright and Co., of Melbourne, as consulting agents to the Company. He thought the shareholders owed to the Board a considerable debt of gratitude in having secured the contract for lighting the Melbourne Exhibition, not only for the profit that was made upon the work, but for the encouragement which had thus been given to an enterprise, in the prosperity of which they were so much interested. He believed that India offered the best field for the electric light.

Sir HENRY HOARE asked if the balance carried down was the amount brought down as debtor balance.

The CHAIRMAN: Yes, it is for the last seven years.

Mr. INCE said he had listened with the deepest interest to the remarks which the Chairman had made, and he was amazed that the Directors were able to carry out the arrangements referred to with respect to the Exhibition at Melbourne with practically no credit at their backs. They must all congratulate the Directors on the successful way in which they had managed the business. He had also listened with great gratification to the remarks which had fallen from the Chairman as to the starting of some central station. He was perfectly confident that the correct course for the Company to adopt would be to raise some further capital for the purpose of erecting a central station at some place which the Board might fix upon. He thought with Mr. Morrison that India would be the best basis to start operations upon with new capital. He believed they would be enabled to pay 7 per cent. upon the capital, and that there would be a handsome surplus on the working of the station; and he believed that, having started one station, it would only be a very short time before they brought the whole of their capital to par, or nearly the whole of it, as it might be wise to write off a part. The shareholders could not hope to achieve the success which they were all looking for unless additional capital were found, upon which, after all, the future of the Company seemed to depend. He would certainly be prepared to take his proportion of any extra capital that might be raised.

Mr. BENJAMIN KISCH desired to add his testimony to the gratification with which the shareholders must have listened to the observations of the Chairman.

Mr. VERITY said that all the shareholders would sympathise with the Directors. They had had a lot of trouble, and business had been bad, but what he wanted to point out was that they had been losing money each

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year, and unless something were done before they next met he thought it would really be a question for the shareholders to talk about shutting up shop.

The CHAIRMAN: I do not see that at all.

Mr. VERITY observed that at their last meeting they had the control of the lamp patents throughout the whole field of their operations, but he believed that a recent judicial decision had altered their position in that respect materially. He could not understand what better position the Company would be in if they found extra capital for the purpose of starting a central station than they would be in if the matter were entrusted to local gentlemen. He considered it doubtful whether four or five gentlemen, members of the Board in this country, could control the working of a central station in the Colonies.

Col. WILKINSON gathered from what the Chairman had said that the Company had secured a most advantageous contract in Melbourne, but he desired to know whether the profit referred to by the Chairman was assured.

The CHAIRMAN: Absolutely assured under a sealed contract, and it will be realised, I should think, by the end of February. Our contract is with the Commissioners of the Exhibition at Melbourne, and under the arrangement it was agreed that within one month after the delivery of the plant and its acceptance by the Commissioners 90 per cent. of the amount which was placed for any particular engine or any portion of the plant should be remitted to England. That has been done regularly on the first Monday of every month, I think. Up to the present time about 90 per cent. of the money due to us has thus been paid. The balance of 10 per cent. will be paid to us within one month of the closing of the Exhibition, and, according to the Company's contract, the Exhibition was to be open for six months only. If it should be open for a longer period the Company will be entitled to cash for the full amount of the contract. I have referred to the statement made by the Commissioners in expressing their satisfaction at the lighting. Perhaps I had better read the extract. They say:—"Referring to the lighting of the building by means of the electric light, the Executive has great pleasure in stating that, after a month's trial of what is stated to be the largest single installation in the history of electric lighting ever attempted by a single company, it has proved a marked success" (cheers).

Mr. McMILLAN said he thought that what had happened during the past year had justified the advice he had given to the shareholders at the last meeting—to leave their affairs in the hands of the Directors. He was pleased to find that the confidence which the shareholders then reposed in the Directors had been fully borne out.

The CHAIRMAN, in further reply to questions, expressed regret that they had not be able to do any business in India. The stock which they had in hand there had been taken over from the Edison Company. The plant used for lighting the Melbourne Exhibition was absolutely sold to the authorities there. It would be taken over by the Government after the closing of the Exhibition and used by them on railways and other public works. They would certainly be able to place some of the Preference shares which might be issued through the Australian Electric Company. They had endeavoured to obtain payment of the calls in arrears, but they had failed to receive any more. The amount was only £1.500, which he did not think a very large sum considering that they had a capital of £120.000. They would probably forfeit the shares, as had been suggested, but they had not wanted to do that until the market price of the shares rose to something like 15s. or a pound, when they would be able to reissue them and get some money that way. The shares had lately been dealt in for the first time for years at a price equal to about 27s. per share, including the liability of 10s. on them. The longest lane had a turning, and he really thought that they could see the corner. They had intended to meet earlier, but delayed in order that they might be able to give some intelligence which would be regarded as of a gratifying nature by the shareholders respecting the working of the electric light at the Melbourne Exhibition. As Mr. Verity must be perfectly well aware, when once a central station was put up there was no difficulty in working the light, nor did he understand how Mr. Verity, in the face of what had been said at the meeting, could say that they were worse off now than they were a year ago. The fact was directly the opposite. He then put the resolution, and it was carried unanimously.

The retiring Directors, Messrs. Van Tromp and Sanderson, and the Auditors, Messrs. Deloitte, Dever and Co., were unanimously re-elected.

On the motion of Mr. INCE, seconded by Mr. VERITY, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN briefly acknowledged the compliment.

It was decided to leave the question of the issue of Preference shares with the Directors.

The CHAIRMAN said that that being so the Directors would, at the proper time, issue a circular on the matter.

The proceedings then terminated.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 9th, 1888, amounted to £5,782.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 9th, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4.728.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Nov. 14, 1888.	Rate per cent. Yielded	Dividend Due.	Business Transacted during Week Ending Nov. 14 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	46 47	2 18 6	Jan., Apr., July, Oct.	47	46½
2,614,820	Stock	15/0	Do. Preferred	77 78	3 10 6	" "	79⅛	77
2,614,820	Stock	nil.	Do. Deferred	15¼ 15½	...	February	15⅝	15½
130,000	£10	5/0	Brazilian Submarine xd and bonus	13⅜ 13⅝	5 5 5	Mar., June, Oct., Dec.	13⅛	13¼
16,000	10	9/0	Cuba Submarine	13¾ 14¼	5 19 9	February and August	13⅜	...
6,000	10	10/0	Do. Preference	18 19	5 5 3	" "	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3¾ 4¼	3 15 4	March & September	...	...
6,000	5	10/0	Do. Preference	9 10	5 0 0	April and October	9	...
60,710	20	2/0	Direct United States	9¼ 10	4 0 0	Jan., Apr., July, Oct.	9 1/16	9⅛
380,000	10	4/6	Eastern	12⅜ 12⅝	4 15 1	" "	12 3/16	12⅜
70,000	10	3/0	Do. 6 per Cent. Preference	14¾ 15¼	3 19 0	" "	14⅛	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	3 18 0	February & August	...	...
250,000	10	2/6	Eastern Extension	13⅛ 13⅜	4 17 2	Jan., Apr., July, Oct	13⅛	13 1/16
22,050	10	8/3	German Union Telegraph and Trust	9 9½	7 7 4	January and March	9	...
179,177	10	1/0	Globe Telegraph and Trust	6¾ 7⅛	4 18 3	Jan., Apr., July, Oct.	7 1/16	6¾
178,992	10	3/0	Do. 6 per Cent Preference	14⅜ 14⅝	4 2 1	" "	14⅝	14⅜
150,000	10	5/0	Great Northern	14¼ 14½	5 1 8	Jan., July, and April	14⅜	14¼
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
33,348	10	3/0	London Platino Brazilian xd	7 7⅛	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7½	5 12 0	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
30,000	10	6/0	West Coast of America	9¼ 9⅝	5 2 7	January and July	9⅜	8⅞
150,000	Stock	8%	Do. Debentures	121 125	6 8 0	June and December	...	...
88,321	10	nil.	West India and Panama	1⅞ 2⅛	...	...	2 3/16	1 13/16
34,563	10	12/0	Do. 1st Preference	12¼ 12⅝	8 12 6	April and October	12⅝	...
4,699	10	*	Do. Six per Cent. 2nd Preference	11½ 12½	...	...	12½	...
45,181	15	6/0	Western Brazilian	13¾ 14¼	5 7 6	March & September	14⅛	13¾
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	118	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance xd	1/16 1⅛	5 10 0	Yearly	...	...
220,000	£1	2½%'87	Oriental (11s. paid)	⅜ ½	2 14 11	...	...	...
80,000	5	10/0	United	13½ 14	5 7 2	June and December	13¾	13 7/16
275,000	5	4/6	United River Plate	5½ 5¾	...	July and January	5¾	5 5/16
	•		**ELECTRIC LIGHT.**					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4 4½	...	...	4½	...
23,692	5	nil.	Do. (fully paid)	5 5½	...	February & August	5 5/16	5⅛
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2⅝	2½
312,000	½	5% '86	Maxim-Weston	1/16 1/8	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	38½ 39½	6 1 3	March and July	39½	38¾
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	16½ 17½	5 14 3	February & August	17⅛	...

* No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 549.—Vol. XXII. FRIDAY, NOVEMBER 23, 1888. Price 4d.

NOTES.

As we announce elsewhere, the Committee of the Electrical Trades Section have decided to recommend the Board of Trade to increase the unit of electrical supply from 1,000 to 10,000 watt-hours. Concerning the reasons for this proposal, our readers may be referred to our leader in the present issue. We believe that good ground exists for this change, notwithstanding that it must give rise for a time to some confusion in the classification of dynamos. The unit of output of a dynamo being a rate of doing work is, of course, distinct from the unit in question, but in practice it has been found desirable that they should each rest upon the same numerical basis. It is to be hoped, therefore, that those dynamo-makers who at present speak of their machines in terms of the unit of 1,000 watts will consent to shift the decimal point. The effect of the value of the electrical unit being further removed from that of the horse-power will, we think, be advantageous in itself.

The meeting held yesterday to promote the laying of a Pacific cable from Canada to Australia, although described as an influential one, was conspicuously wanting in men of practical knowledge and experience connected with submarine cable laying. Probably this fact will account for the extraordinary statements confidently put forward from the platform to induce the audience to take a favourable view of the financial aspects of the scheme. Of course the merchants and shippers present were decidedly anxious to reduce the Australian cable tariff; but it by no means follows that these gentlemen will provide the money for reducing rates out of their own pockets, still less that the British Government will do so.

We commend to the notice of the Gas Journals, who are still much exercised in their minds over the Deptford Scheme, the letter of our New York correspondent in the present issue, in which he quotes the President of the American Gas Light Association, who, in a recent address, set himself to discover the reason for the great increase in the consumption of gas in the States. He arrived at the conclusion—not, indeed, a novel one—that the main reason was to be found in the extension of electric lighting, which had the effect of compelling people to use more light in every direction. Let the gas interest, therefore, again take heart of grace, and welcome the electric light as a true ally and indeed its very best friend.

In a leading article which appeared in our contemporary the *Electrical Review* last week on "The Future of Electric Railway Traction," we read that "Mr. Sprague himself was compelled to admit that accumulators are the only safe means as a motive power for street cars, and are therefore to be looked forward to in the future as the solution of the difficulty of electric traction for public thoroughfares. All this," proceeds our contemporary, "is very gratifying, but it does not in the least take us by surprise, as in this country there are not many electricians who would think otherwise, and we must take it that this question has already been settled in everybody's mind." As a general rule we do not care to criticise the views of contemporary English journals, and if we make an exception upon this occasion it must not be supposed that we are actuated by any hostile feeling. We do, however, feel bound to demur to the statement—coming from so influential a quarter—that English electricians have, as a body, arrived at the conclusion that the storage cell affords the only practicable solution of the electric traction problem. Our own impression is, indeed, very much to the contrary. Undoubtedly, an ideal solution would be furnished by an *ideal* cell. But how nearly does any cell in the market approximate to the ideal? We take it that such a cell will depreciate at one-nth the present rate, and will have n times the capacity with one-nth the weight per horse-power—the value of n being certainly not less than three or four.

Since writing the above we have turned to see what Mr. Sprague really did say on the subject (*The Electrician*, Nov. 9, 1888, p. 29), and we find that his views are practically identical with our own. "They will never," he says, "take 20,000 pounds weight up a 10 per cent. grade with a storage battery until it is in a good deal higher state of efficiency than it is to-day." Mr. Sprague then goes on to speak hopefully of an improved cell with which he is himself experimenting; and most sincerely do we trust that he, or somebody else, will meet with success in this direction. The relative merit of the overhead system is a question which has little more than academic interest in this country; but as to our contemporary's expressions of satisfaction in the attack of Mr. Leonard on the Richmond line, we have only to remark that the fact that even a moderate success should have been attained with such a rough-and-ready mode of erection poles stuck in the mud, and so on—speaks strongly in its favour; and at least it should be remembered that over fifty lines are now at work in America on this principle. The letter of our New York correspondent in this issue contains an account of a line at Topeka, fourteen miles

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in length, with from thirty to forty cars, and involving an expenditure of over £40,000. This is to be worked by an overhead conductor. It is to be erected by the Thomson-Houston Company, and the Thomson-Houston Company are generally credited with a tolerably competent knowledge of what they are doing.

We believe, nevertheless, that storage cells have not yet been permitted to show what they really are capable of doing for electric traction. We refer to the fact that in every case that has come under our notice arrangements have been provided for coupling the cells in one or more sets in parallel so as to obtain a convenient E.M.F. for starting the motor and for variations of speed. In theory this is of course a highly tempting arrangement, particularly as it involves no immediate waste of energy; but in practice we regard it as most pernicious, and we are at a loss to account for the fact that those who are interested in the success of accumulators have so long tolerated it without protest. It is simply impossible that any set of cells should all have identically the same E.M.F., and wherever the slightest inequality exists the cells, if coupled in parallel, are placed in a condition of unstable equilibrium. When a cell once begins to take a discharging current it is never given any chance to recover, but is bound to go from bad to worse. We should therefore like to see all battery tramcars provided with a simple rheostat arrangement for starting on; and we believe that the extra cost would be defrayed many times over by the increased life of the cells.

Turning to another side of the traction question, a letter will be found in our correspondence columns in which Mr. Sprague replies to the recent criticism of Mr. Albion T. Snell. As Mr. Snell will no doubt have something to say on the subject next week, we content ourselves with the remark that Mr. Sprague scarcely does justice to the constructive part of Mr. Snell's criticism, in which he suggested a novel—and to our thinking a most valuable—method of determining the nature and extent of the internal losses in a motor. Mr. Sprague's plan of deducting ten per cent. from the electrical efficiency is doubtless good enough for many practical purposes, but then the original Paper (*The Electrician*, August 3rd, 1888, p. 409), upon which Mr. Snell's criticism was based, professed to be a full analysis of the performance of the Sprague motors, and for such a purpose a ten per cent. allowance for unknown losses is undeniably crude.

With reference to the letter which appeared last week under the heading of "Globular Lightning," and which we spoke of at the time as one of the most extraordinary statements of the kind which had come under our notice, we have since been given to understand that the books of the United Telephone Company contain no record of any indicators having been returned as damaged by lightning at the date quoted. Our informant also casts additional doubt upon the reliability of the source from which Mr. Wordingham obtained the story, stating that the line-foreman in question is well known to have been subject "to some very strange delusions." Having allowed the story to appear in our columns we feel bound to publish the above statement in the interests of scientific accuracy.

The third annual report of the Old Students' Association of the City and Guilds of London Technological Institute (to quote its full style and title), which now lies before us, offers such plentiful evidence of vitality that it is impossible to doubt that the future of the Association will be permanently and increasingly successful. There are now on the roll no less than 142 Members and Associates, of whom 49 were elected during the past year. The movement was originally started in connection only with the Finsbury Technical College, but in December last the title of the Association was altered as above with a view of extending the membership to the Central Institution in Exhibition-road, and the other branches. Under the Presidency of Mr. W. F. Pettigrew, 14 meetings in all have been held, including in that number a visit to the London and South Western Railway Works, two highly successful Smoking Concerts, and the Annual Dinner. Out of the nine Papers which were read at the ordinary meetings no less than six dealt with electrical subjects. Each of these Papers was submitted for examination to Professors Thompson, Meldola and Perry, who have awarded the Medal of the Association to Mr. Regd. J. Jones, for his Paper on "Installation Breakdowns." In communicating the decision of the examiners, Prof. Perry said "The Papers are all such as would be gladly accepted by the Councils of the various Societies before which Papers on such subjects are read." Perhaps we may be permitted without impropriety to express our entire agreement with Prof. Perry's remark. A higher tribute to the success both of the Association and the Institute with which it is connected it would be impossible to give.

It is pleasant to note that the Westinghouse men who are now in this country speak enthusiastically, not only of the outlook for the alternating current in general, and of the great organisation with which they are associated in particular, but also of the highly remarkable man who is at the head of its affairs. Mr. Geo. Westinghouse, jun., without being a highly-skilled electrician, has evidently a competent knowledge of the details of electrical engineering; and while he has in his employ a number of electricians—several of them Englishmen—of more than average merit, yet his own advice and experience has probably had more to do with the extraordinary success of the Company than is generally supposed. The wise and liberal policy adopted by the Westinghouse Company towards its technical officers has also undoubtedly contributed largely to that success. In this respect we are sorry to have to believe that with but few exceptions the leading English electrical firms and companies will not stand a favourable comparison. It is an open secret that the majority of the men who occupy similar positions in this country are by no means contented with the treatment which they receive. The grounds of this discontent are not always the same, and probably it is not always in the power of the company to remove them. But a better state of things would undoubtedly exist if the identity of interest which subsists between the company and its technical officers were more fully recognised. The Westinghouse Company seems

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always anxious to acknowledge the share of each of its *employés* in the development of their system; and we believe we are correct in saying that it adopts the principle of attaching as far as possible the name of one of its technical officers to each of the principal features of its system. This spirit—although by no means altogether wanting here—has been conspicuously absent in some cases we could name; and there are men who have done good work whose names are scarcely known in the profession owing to the unwillingness of their employers to let it be seen how much they have been indebted to the scientific ability of their own officers. This is a short-sighted policy, and in the long run does not conduce to the reputation of the employers.

A RECENT correspondent of *The Times* advocates the teaching of physical science as a cure for national mendacity, which he (and others beside him) thinks is growing at an alarming pace. In this case the evil, if not the cure, is to be sought in the region of politics. The art of public mendacity has been cultivated just in proportion as the audience on which it can be profitably practised has been popularised. If physical science teaching would cure the democracy of its toleration of untruths the "Cry for Useless Knowledge" ought to be answered at once, notwithstanding Lord ARMSTRONG. But it would be simpler and cheaper to begin at the other end. Why not make admission to Parliament subject to a rigid examination in physical science? Here again, however, we should have to take coercive measures against people called "Crammers," if we really desired to put an end to the telling of things which go by that name.

"CAN such things be?" Apparently they can, for, unless the *Newcastle Leader* has been hoaxed, the Hexham Local Board is discussing with perfect seriousness an offer of Mr. MILBURN to light the town with primary batteries and 10 candle-power lamps (!) *at the rate of ½d. per dozen lamps per hour.* We devoted some little space to Mr. MILBURN last week, and have no room to do more than to assert with all due solemnity that the scheme is utterly impracticable; and upon this statement we are prepared to stake our professional reputation.

The Patents Bill.—On the order to go into Committee on the Patents, Designs, and Trade Marks Bill last Monday, Mr. Biggar objected, and, although appealed to by Mr. Mundella, persisted in his objection, and the order was postponed.

Paddington Vestry.—The Electric Lighting Committee of the Paddington Vestry has been authorised to obtain the advice of Prof. George Forbes upon the electric lighting scheme. Prof. Forbes has undertaken to furnish a report with plans by March 30th.

Renewal of Patents.—Mr. A. V. Newton has issued an address in pamphlet form recommending the reduction of fees for renewal of patents. The Patent Office is making a large profit, and Mr. Newton argues that the total cost of a patent should be reduced, or that the renewals should be in small sums spread over a longer period.

Illegal Fishing for Salmon and the Electric Light.—A Newcastle paper says:—We understand the Police Committee of the Tweed Commissioners are anxious to charter a steam tug to carry lights of 2,000 candle-power to search for nets set in the sea to catch salmon. Considerable difficulty, however, has been experienced in obtaining a vessel, the owners not caring to run the risks of the venture.

The Waterhouse System.—The Waterhouse Electric Company (of which Messrs. Shippey Brothers are the agents for England) have been awarded the Gold and two Silver Medals, at the recent Centennial Exhibition, Cincinnati; also two diplomas, the Gold Medal, and three cash prizes at the Californian State Exhibition. This system seems to be making headway throughout the States.

Society of Telegraph-Engineers and Electricians Students' Meeting.—A Students' Meeting was held on Thursday, November 15th, Prof. J. A. Fleming, M.A., D.Sc., in the chair. Mr. C. G. Lamb, B.Sc., read a paper entitled "A Résumé of the Question of Electrical Oscillations." Prof. Fleming also made some remarks on the same subject. A short discussion followed, in which Messrs. E. W. Smith, W. H. Shephard, and Rance took part.

Robey and Co.'s Engine at Glasgow.—We learn that the very fine 300 horse-power Robey engine used in the Electric Light Department at the Glasgow Exhibition is to remain in Glasgow, having been purchased by Messrs. J. and G. Thompson, the well-known engineers and shipbuilders, Clydebank, Glasgow, for their own use. Considering the number of engine builders there are in Glasgow, many of whom had engines in the Exhibition, this is undoubtedly a high compliment to Messrs. Robey and Co.

A Small Tragic Incident.—Mr. H. Palethorpe writes us from Dudley, as follows:—"For the last three years I have run a 4,000 candle-power arc lamp at the top of my sausage factory, Market Place, Dudley. Last Saturday evening, after burning for about two hours, the lamp stopped. The engineer went up to learn the cause, when he found a little bird, smaller than a sparrow, between the carbons, quite burnt up. The little fellow, attracted by the glare, had entered the lamp through a broken part of the globe."

The Telephone in Finland.—A correspondent writing from Nystad sends us the following interesting information respecting telephonic enterprise in Finland. A telephone line has just been completed between the towns of Abo, Nystad, Raumo, and Bjorneborg, a total distance of 168 versts (113 miles). The transmission is good, although the line runs nearly half the way parallel with Government telegraph wires connecting the cable station of the Great Northern Telegraph Company with St. Petersburg. Two of these wires are worked with the Hughes apparatus, which gives rise to rather strong inductive effects.

The Electro-Harmonic Society.—The concert of this society on November 30th (which is a "Ladies' Night") promises to be of a specially attractive character, a programme of peculiar excellence having been arranged for. The following amateurs have kindly consented to take part:—Mrs. A. Siemens, Miss Spagnoletti, Mr. George Clues, Mrs. Theobald, Miss Mary Doughty, Mr. T. H. Harrison, Miss Edith Doughty Mr. T. E. Gatehouse, Mr. W. Stepney Rawson, Mrs. J. Elvin, Miss Rawson, Miss Margaret Doughty, Mr. Alex. Siemens, and Mr. Alfred Izard. There will also be some recitations by the Rev. George Bell Doughty.

Electric Lighting Overhead Wires.—In the House of Commons, on Thursday, the 15th, in reply to Mr. Bradlaugh, Sir M. Hicks-Beach said that no overhead wires for the purpose of electric lighting had been sanctioned so far. He could not make any definite promise with regard to future applications on the subject with reference to the metropolis; but certainly he

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should not be disposed to sanction such appplications. Mr. Brunner asked whether the right hon. gentleman had power to prohibit the erection of such wires in the metropolis, and Sir M. Hicks-Beach in reply said that was a question he would rather not answer at present.

The Radiometer.—Mr. W. Crookes has presented to the Department of Science and Art a collection of 68 radiometers and similar instruments, for permanent exhibition in the Science Galleries of the South Kensington Museum. They illustrate the steps by which he was led to the construction of the radiometer, and to the production of motion and of phosphorescence by streams of electrified molecules in high vacua. Many of the instruments are of the greatest historical interest. Among them is included the first radiometer, with many others, which are described in Mr. Crookes's Papers in the *Philosophical Transactions* of the Royal Society. Nearly all the instruments are in working order.

The Indian Telegraph Service.—A Calcutta paper says:—"The Sub-Assistant Superintendents of the Telegraph Department are about to memoralise the Director-General against the exclusive recruitment of Assistant Superintendents from England, a practice which shuts the Sub-Assistants out from all hope of rising to a higher rate of pay than Rs. 350 a month, and is besides contrary to the promises contained in the late Colonel D. G. Robinson's memorandum on reorganisation, which has since 1865 been regarded as the basis of the term of service. What the memorialists ask is that the present impassable gulf between the two grades should be bridged over by the promotion of experienced sub-assistants, who would thus, as a class, be given the prospect of reaching Rs.450 a month before retirement."

Electric Transmission of Power at Weissembach.—A cement manufacturer at Weissembach, near Triestang (Austria), finding it necessary to increase the power at one of his two mills, placed the matter in the hands of the firm of Siemens and Halske. The two mills were 300 metres apart, and at one of them a 3-metre waterfall was available: here a 20 horse-power Jouval turbine was installed. This turbine drives a 11½-unit compound Siemens and Halske dynamo, running at 1,000 revolutions and giving 90 amperes at 130 volts. The motor at the other mill is also a Siemens-Halske compound machine. Arc and incandescent lamps are run off the transmission circuit, so that the dynamo drives the motor by day and supplies the lamps by night; a few lamps can be run during the day time without disturbing the power circuit.

Progress in New Zealand.—The *Marlborough News* of August 17 says that the Borough Council of Timaru, after an interview with Mr. Ashcroft, jun., who submitted an offer to light the streets with electricity, resolved to instruct the Works Committee to prepare specifications on which the electric company and local gas company may tender for lighting the streets with about 100 lamps. It is also stated that the works of the Reefton Electric Light and Transmission of Power Company have been finished, and a satisfactory trial has been made. It is expected that by the end of the month the light will be in use in every street and dwelling in the town. The price charged is £3 per lamp per year, which is equal to 5s. per light per month. The entire plant cost £5,000, and was erected by W. Prince, of Dunedin. The shares of the company, on which 5s. is paid up, are now quoted at 3s. 3d., and are sought for.

Swansea.—At the last meeting of the Swansea Town Council, Mr. Martin moved the adoption of the minutes of the special committee *re* gas, which recommended that tenders be invited for the lighting of an area including the following streets:—Somerset-place, Mount-street, Wind-street, Castle-square, Castle-street, High-street (to Prince of Wales-road), Alexandra-road, Grove-place, De-la-Beche-street, Cradock-street, Union-street, Northampton-place, Dillwyn-street, Oxford-street, Goat-street, Temple-street, and Caer-street, and, to a certain extent, the streets leading therefrom. The present cost of lighting this area is £539. 13s. 8d. per annum, and the surveyor estimates that to light the same with electricity will cost an additional £175 per annum, or 30 per cent. more, while the illuminating power will be raised from 3,288 to 44,400 candles. It was decided, on the suggestion of Mr. Martin, to invite tenders for lighting the streets named by electricity.

The Wearing of Commutators.— Mr. Roger Tatham, of Rochdale, has recently devised an arrangement intending to prevent the uneven wearing of dynamo commutators. The brush-holder bars are free to slide to and fro, a cross-bar connecting them to secure simultaneous movement. A slow reciprocating motion is imparted to the brushes by means of a worm on the commutator which gears into a threaded shaft, which in turn gears into a cog-wheel provided with a connecting rod coupled to the brush-holder bars. The to-and-fro motion thus imparted to the brushes, it is claimed, ensures practically even and uniform wearing of the parts. By a somewhat similar contrivance an emery wheel or polisher is caused both to rotate and traverse to and fro, so that should the commutator be worn it can by this arrangement be easily turned true in its place. In cases where machines are required to work with the least possible alteration the device will probably be found useful.

Statistics of the Western Union Company.—The following table gives some interesting figures relating to the progress of the Western Union Company during the last twenty years. Between July, 1866, and the present time this company has paid the sum of 52,385,565 dollars (£10,477,113) in dividends. It should be remembered, however, that the apparent growth has been, in reality, largely due to absorptions of competing telegraph companies:—

Date.	Length.		Offices Open.	Telegrams Transmitted.	Revenue in Dollars.	Net Profit in Dollars.
	Line in Miles.	Wire in Miles.				
1868—1869	52,099	104,584	3,607	7,934,933	7,316,918	2,748,801
1878—1879	82,987	211,566	8,534	25,070,106	10,960,640	4,800,440
1883—1884	145,037	450,571	13,761	42,076,226	19,632,939	6,610,435
1884—1885	147,500	462,283	14,184	42,696,583	17,706,833	5,700,924
1885—1886	151,832	489,607	15,142	43,289,807	16,298,638	3,919,855
1886—1887	156,814	524,641	15,658	47,594,530	17,191,910	4,037,281
1887—1888	171,375	616,248	17,241	51,463,955	19,711,164	5,070,572

The Cost of Electric Lighting.—Messrs. Carey and Fricker (of 12, Delahay-street, S.W.) have issued a useful pamphlet on the above subject, which is designed to disabuse the public mind of the idea that the electric light is excessively costly, and that it possesses a dangerous and ricketty constitution. The writer—who states his case with commendable brevity and lucidity—does well to insist on the fact that the improvements which have of late years been effected in the design and construction of dynamos, lamps, and engines, have placed the business of electric lighting upon an assured footing, and, so far as isolated installations are concerned, have reduced it to the level of any other piece of engineering in which, in competent hands, there is nothing whatever of an uncertain or experimental nature. A diagram is given, showing the relative cost of gas and electric lighting for installations in mills and factories where a period of 1,500 hours of lighting per annum is attained. In this case, electricity ought undoubtedly to be cheaper than gas at 3s. where fairly large installations

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are concerned; but we doubt whether the difference is quite as great as the writer supposes.

Sheffield.—On Saturday evening, by special permission, the members of the Sheffield Society of Engineers, about 40 in number, inspected the machinery and plant at the electric light station of the Sheffield Electric Lighting and Telephone Company (Limited). Mr. Fred. Tasker conducted the party, and explained in detail the construction and arrangement of engines and dynamos, storage batteries, &c. The main driving engines consist of a horizontal tandem compound, and high pressure coupled cylinders, of 40 horse-power, driving three "Thomson-Houston" dynamos, giving collectively a light equal to 300,000 candles; also a Phœnix dynamo, for charging the storage batteries. This station was described and illustrated in our issue of January 13th, 1888. At 8:15 the members adjourned to the Central Telephone Exchange. The arrangements for establishing communication between subscribers was courteously explained by the attendant in charge. The new American multiple board is now used, through which 30,000 messages per week are sent by over 500 subscribers. Seven miles of wire are used in connecting up this board, and there are about 5,400 separate soldered joints attached.

A New Arc Lamp.—We were asked the other day to witness a run with a new arc lamp patented by Messrs. Chapman and Dearing, of 345, Mile End-road. The negative carbon is fed up vertically by a rather crude arrangement (this, however, is to be replaced by a device somewhat of the Pilsen order), the arc being formed between it and the point of contact between two horizontal carbons in a straight line with one another and fed forward through tubes by springs. The lamp had been built to suit the machine driving it, and according to the ammeter in circuit, which we were told read about four amperes too high, was taking rather over 25 amperes. With this current the lamp burnt very fairly well, and so far as we could judge there appears to be some truth in the inventor's claim that it spreads the light considerably more than in the ordinary vertical carbon type. We were under the impression that Rapieff had covered all possible forms of this type; but the inventors maintain that he never used his positive carbons in the same straight line with one another forming a plain T with the negative, but always at an angle, and as it seems that they have obtained the German patent on appeal this is probably correct.

Royal Meteorological Society.—The first monthly meeting of this society for the present session was held on Wednesday evening, the 21st instant, at the Institution of Civil Engineers, 25, Great George-street, Westminster, Dr. W. Marcet, F.R.S., President, in the chair. The following Paper was read:—"Results of an Investigation of the Phenomena of English Thunderstorms during the years 1857–59," by Mr. G. J. Symons, F.R.S. This Paper was written nearly thirty years ago. It has now been communicated to the society at the request of the Thunderstorm Committee. The Paper contains a summary, chiefly in statistical form, of some of the results of an investigation into English thunderstorms and the accidents produced by lightning during the years 1857–59. The author found that in sheet lightning the most prevalent colour is white, then yellow, blue, and red; in forked lightning the order is nearly reversed, blue being more than twice as frequent as any other colour, then red, white, and most rarely yellow. Sheet lightning was seen about twice as often as forked.

The Hermite Process of Electro-Bleaching.—Mr. Hermite recently delivered a lecture at the University College, Nottingham, on the process of electrolytic bleaching with which his name is associated. He pointed out that advantages of the process were that every bleacher was enabled to produce his own bleaching agent, that there was greater economy than in the old processes, that the destruction of the fibre was inappreciable, and that the cost was constant. The first operation in the process was the electrolysis of a solution of magnesium chloride. By this the water and the salt were both decomposed, and the nascent oxygen of the water and the chlorine of the salt united, producing a very unstable compound, of intense bleaching power. The hydrogen gas and magnesium went to the negative electrode, and the latter formed magnesium oxide with the water, the hydrogen being disengaged. If in this liquor were introduced any coloured vegetable matter, the oxygen compound above mentioned at once bleached it, whilst the liberated chlorine combined with the free hydrogen to form hydro-chloric acid. This in its turn decomposed the magnesia, producing the initial chloride of magnesium. Therefore a complete cycle of changes went on in the process, and there was nothing exhausted except the water, which cost nothing. Mr. Hermite concluded by pointing out that in this process only half the motive power was necessary to bleach the same weight of coloured material as in the old processes, thus effecting a saving of 40 or 50 per cent. to the bleachers.

Kensington Vestry.—The following is a fuller summary (taken from a local journal) of the discussion at the Kensington Vestry, to which we referred briefly last week:—"The special committee appointed to consider matters on electric lighting reported that they had received a letter from the House-to-House Electric Light Supply Company (Limited), stating that several residents in Barkstone-gardens, Bramham-gardens, and Collingham-gardens were desirous of having a supply of electricity from the company's works adjoining the West Brompton Station, and that the owners of the new streets mentioned had consented to the laying of underground mains therein, provided that the same was done in compliance with the requirements of the vestry, and requesting permission to take up a portion of Richmond-road from the company's central station to Kempsford-gardens, through Kempsford-gardens and Earl's Court-square, across Earl's Court-road to Bramham-gardens, and along Earl's Court-road to Barkstone-gardens, for the purpose of connecting mains. The committee recommended, after great deliberation, that permission be given to the House-to-House Electric Supply Company (Limited) to lay down mains, &c., along the streets referred to in the application by way-leave, upon condition that, in the event of any general system being hereafter adopted by the vestry for the laying of mains, &c., the company undertake to change the mains now proposed to be laid in such manner as to conform to, and generally to be subject to, such future system. All the mains, &c., now proposed to be laid down, to be laid in such part of the roadway or footway, and generally on such conditions and in such mode, as may be approved by the vestry's surveyor. Several more or less incomprehensible amendments were put forward amid exciting speeches, but all were lost. Then, suddenly, toward midnight, Mr. W. A. Lindsay proposed that all electric lighting companies be given power to apply for a provisional order to carry on operations in the parish. This was seconded and carried by a large majority. A division was claimed, with the result that Mr. Lindsay's amendment was again carried by 38 votes to 19. Several members cried out that it was putting back two years' work, and many speeches were made as to the danger existing for the parish being placed at the mercy of the electric lighting companies. Mr. Duffield and Mr. Jordan said they would resign. The two years' labours of the committee had been undone. Mr. Campbell then proposed that the matter be adjourned for a fortnight. This was agreed to without a division."

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LIGHTNING CONDUCTORS.—III.

BY DR. OLIVER LODGE.

(Continued from page 9.)

Further Alternative-Path Experiments, April, 1888.

20. A spark micrometer was now constructed out of a micrometer screw arrangement obtained from Lutz, of Paris, as part of a "Desains' apparatus" for measuring Newton's rings. It is depicted in various optical books—say, "Jamin et Bouty." Insulated knobs (of diameter, one 1·940, the other 1·965 centimetres) were supplied to this, and the distance between them could be varied and read with great ease and accuracy.

The pitch of the screw was one millimetre, and its micrometer head was divided into grades, so that actual readings were in 400ths of a millimetre. Seldom, however, was it necessary to read so close as this.

This instrument was always used henceforth to measure the length of the B spark. Knowing this length, the corresponding potential can be determined as follows :—

Connexion between Differences of Potential and Length of Spark.

21. The potential needed to give a spark in air between two flat plates d centimetres apart is 110 d electrostatic units, or 33,000 d volts. The corresponding spark length between two large spheres, of radii r and r' respectively, is b, where

$$\frac{1}{d} = \frac{1}{b} + \frac{2}{3r} - \frac{1}{3r'}.$$

(*See* Maxwell's "Electrical Papers of Cavendish," p. 386.)

In the present case the knobs are not large enough, in comparison with the usual length of spark, for this formula to accurately apply, but the error cannot be great if we take the potential corresponding to any very short spark, expressed in fractions of a centimetre, between the above micrometer knobs (which are each about 1 centimetre radius), as

$$\frac{99000\,b}{3+b} \text{ volts.}$$

For longer sparks or smaller knobs one must make a special series of experiments to compare one with another, and link all the different sized knobs together into one set, so that all their readings can be interpreted. To this end I have recently made a series of experiments, arranging all the pairs of knobs commonly used in parallel with a couple of large spheres, and adjusting them all so that a spark was willing to choose any of the intervals at random. The large spheres were more easily manageable than a couple of flat plates would have been; while calculation from them to flat plates is easy for all the lengths of spark tried. The results are shown in the annexed Table :—

Corresponding Lengths of Spark between Different Sized Spheres, Simultaneously Compared (Expressed in Centimetres).

Spark Micrometer Knobs, {1·97 / 1·94} cms. diameter. Commonly used for B spark.	Knobs of Voss Machine, {2·34 / 2·34} cms. diameter. Often used for A spark.	Universal Discharger, {1·38 / 1·41} cms. diameter. Often used.	Large Spheres, 12·1 cms. diameter. Used to compare with the others.	Corresponding Spark Length, calculated for flat plates from the preceding column. $\frac{18b}{18+b}$
·843	·87	·92	·86	·82
1·010	1·02	1·11	1·00	·95
1·410	1·38	1·62	1·33	1·24
1·455	1·41	1·74	1·41	1·31
1·783	1·73	2·28	1·60	1·47
2·130	1·93	3·30	1·74	1·59
2·365	2·17	3·70	1·85	1·68
2·638	2·37	4·14	1·97	1·78
2·972	2·57	5·60	2·10	1·88
4·361	3·85	7·92	2·50	2·19

Hence the length of A spark, 2·4 centimetres, between the knobs of the universal discharger, corresponds to a length of 1·50 centimetre between flat plates, and therefore to a potential difference of 50,000 volts.

Comparison of Wire, Gauze, and Foil.

22. In continuing the alternative-path experiments the first question I wished to examine was how far the distribution of the same amount of substance over different surface would affect the result ; I wished, in fact, to compare a round wire, a flat strip, and a bundle of detached wires, all as nearly alike as possible.

Three alternative paths were therefore prepared, each exactly 218 centimetres (about 7ft.) long. One was a piece of No. 12 copper wire, weighing 91·6 grammes. Another was a ribbon of copper foil 6·4 centimetres wide, and weighing 88·7 grammes. The third was a strip of fine regular copper wire gauze of the same width as the foil, consisting of 154 parallel wires, each about No. 34, with a corresponding woof. The weight of the whole gauze is 136·12, but only half this is effective, so its effective weight is 68·1 grammes. The total surface exposed by the foil is 12·8 times its length ; the surface exposed by the wire is ·77 times its length ; and the surface exposed by the effective wires of the gauze strip is 8·23 times its length.

The resistances, measured in an ordinary way, ought to be inversely as their weights, or roughly the same ; but, as so often happens, the copper wire turned out a bad material, and these were the results :—

Resistance of copper foil	·01125	ohm.
" " " gauze	·02931	"
" " " wire	·02446	"

23. The two gallon jars in series were used as before. The B knobs were those of the spark micrometer. The A knobs, however, instead of being those of the machine as heretofore, were the smaller knobs of a universal discharger, which was employed in order to obviate danger of any variation in the length of the A interval by reason of shaking.

The alternative path was sometimes connected to the outside of the jars direct, sometimes direct to the knobs of the spark micrometer. Hitherto no special care had been taken about this because the alternate paths used were so long ; but now that one began to use much shorter ones it was necessary to be careful where they were connected. Connecting them as directly as possible to the B knobs is plainly the best plan. As this had not been usually done hitherto, it was necessary to examine what sort of difference would be made by the change. The A knobs were adjusted to a distance of 2·4 centimetres apart, and the critical length of B sparks, when about half of them failed, is recorded below :—

Alternative Path.	Length of B Spark. Cms.
No. 12 copper wire, enclosing maximum area, and connecting outer coats of jars direct	·743
The same, but connecting B knobs direct, as in Fig. 5	·552
Ribbon of copper foil connecting B knobs, and enclosing area	·268
The same, but distorted from circular into long U form, so as to enclose much less area	·242
Ribbon of copper gauze, connecting knobs and enclosing area	·267
The same, but connecting outer coats of jars	·414
No alternative path at all. (Frequent spitting at A)	2·118
No. 19 copper wire round theatre, connecting knobs	1·649
The same, but connecting jars	1·698
No. 27 iron wire round theatre, connecting knobs	1·682
The same, but connecting jars	1·663
High liquid resistance, connecting knobs	2·080
No alternative path	2·080 or 2·00

But when no alternative path is used, the critical B length is less definite and sharp, and, instead of a single weak spark as with a high resistance, there is frequent fizzing and spitting at A ; though a strong spark passes at A whenever the B spark occurs.

24. Henceforth, the alternative path was connected direct to the knobs of the spark micrometer, so as to have no uncertainty about the effect of the short leads joining the outer coats of jars to these knobs.

In the next set of experiments, the same arrangement was continued precisely, except that sometimes two pint jars were

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employed instead of the two gallon jars. The A spark was 2·4 centimetres as before.

	Alternative Path.	Length of B Spark.
Two pint jars; capacity in series, 733 centimetres.	None	1·906
	Liquid resistance	1·990
	No. 19 copper round room	1·380
	No. 18 iron „	1·358
	No. 27 „ „	1·305
	No. 1 copper „ with short stranded connections	1·297
	No. 1 „ connected direct	1·280
Two gallon jars; capacity in series, 2,800 centimetres.	The same	1·628
	No. 27 iron round room	1·628
	No. 18 „ „	1·675
	No. 19 copper „	1·675

In these experiments the iron is not maintaining its former position of superiority with respect to copper; *see* § 16. Thin iron is no longer able to beat the thickest copper, but appears about on an equality with it.

25. Since this seemed possibly due to a difference in the arrangement of the A part of the circuit—the part containing the jars, and which in the first of this series of papers we called the L loop, a part which hitherto had not been much attended to—the following modification was made:—One of the two gallon jars was connected up to the machine by means of one of the long leads round the theatre, so as to increase the self-induction of this part of the circuit enormously. The experiment was now repeated, with entirely fresh results. Everything else was the same as before.

	Alternative Path.	Length of B Spark.
Two gallon jars, but with one of them joined to machine through the No. 19 copper wire round the room.	No. 18 iron	·782 centim.
	None	2·618 „
	No. 1 copper	·551 „
	No. 27 iron	1·074 „
	No. 1 iron	·585 „

This experiment shows how vital is attention to every part of the circuit if the result is to be thoroughly understood. Hereafter, therefore, the circuit containing the jars and A knobs was much more carefully constructed, so that its dimensions could be exactly ascertained.

This last experiment is, moreover, the first to which we can apply our theory as set forth in the first of these articles. It does not happen to apply in its simplest form, however, when resistance can be neglected. The resistance of the long, thin leads seems to be an appreciable item in their impedance, and we shall have to take it into account.

(To be continued.)

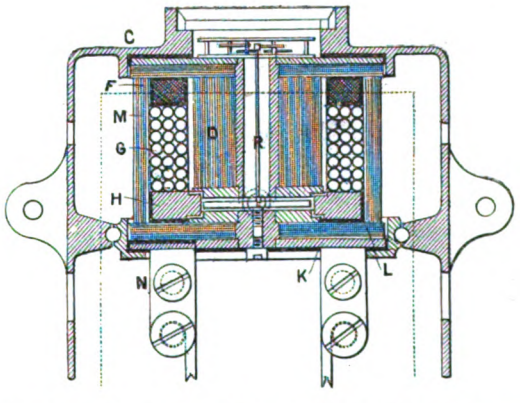
THE GROSVENOR GALLERY CENTRAL LIGHTING STATION.—II.

We this week supplement the account of the Grosvenor Gallery Central Station given in our issue of November 9th with a few additional details. We have already mentioned that the total number of lamps wired for this service is about 35,000. The number of customers at present supplied amounts to nearly 300, and the average power per installation is over 3,500 watts. This high figure arises from the fact that so many of the installations are fitted in theatres, restaurants, clubs, &c., and that the minimum charge made by the London Electric Supply Corporation is £20 per annum, so that small consumers are deterred from using the light. The current is to all intents and purposes always available, since the supply is only cut off once a week for about seven hours, and this early on Sunday morning.

The steam plant, it will be remembered, consists of four engines—two 35 horse-power (nominal) single-cylinder, Marshall, one coupled 500 horse-power, Marshall, and a 750 horse-power Corliss engine; one of the large dynamos being driven by the Marshall engines through countershafting, the other direct from the fly-wheel of the Corliss engine by rope gearing. The manner in which economical working is attained with these rather complicated arrangements is certainly very ingenious. The minimum output of the station is about 120,000 watts, which is quite sufficient to employ one of the Marshall engines economically. When, therefore, the demand upon the station is at its lowest, one Marshall is alone employed to drive the big Ferranti machine. As the demand increases, the second engine is started, the clutch coupling is thrown into gear, and the load is divided between the two engines; and later on the third Marshall engine is brought into play in the same way. When, however, the demand for current approaches the limit of the one dynamo, the Corliss engine is started on the second dynamo, which is brought up to the standard speed on open circuit, and the whole of the load is then transferred to this machine. This transfer is effected in a very simple manner. Each of the five main switches controlling the external circuits can be made to connect them with either machine. By means of these switches one circuit after another can be quickly transferred from the one dynamo to the other. As the output continues to increase the Marshalls are again started one by one, and the load is divided between the two dynamos. The same cycle of operations is gone through in the reverse way, as the demand upon the machines gradually declines to the minimum again. By these combinations a very fair degree of steam economy is attained, each engine being brought into use as soon as there is a sufficient load for it to manage. The switching on and off is so well effected that nothing beyond a momentary blink in the lights is noticed by the consumers.

The Ferranti Meter.

Since its first introduction, the Ferranti meter has been greatly improved in several important details. One of the latest forms is shown in the accompanying figure. The shunt



coil employed to give the field an initial value, independent of the current to be measured, is seen at F, G being the series coils and H a bronze disc, the whole being surrounded by laminated and insulated sheets of cast iron, M, which connect the laminated discs C and L. The rod R actuates the clockwork, and plunges in a mercury bath at H. The current enters at the terminal K, passes through the mercury to H, and thence through the series coils to the terminal N. Under the influence of the magnetic field and the current the mercury is caused to rotate, and as the resistance to rotation due to friction is proportional to the square of the speed, and the turning moment is proportional to the square of the current, the number of revolutions performed in a given time is a measure of the quantity of electricity which has traversed the meter in that time. Owing, however, to the resistance due to friction not following the above-mentioned law absolutely, and owing also to the friction of the clockwork, a sensible error is introduced. This error M. Ferranti ingeniously overcomes by employing the shunt coil already referred to, which secures an excess of electromagnetic action at the very moment when the frictional resistance of the clockwork is great, as compared with that of the mercury, *i.e.*, when the current is small. Further improvements are contemplated in this meter, and a very costly plant of American design is at the present moment being laid down at Mr. Ferranti's factory, for the purpose of turning out the improved type in large numbers. As many as fifty complete meters will be manufactured daily as soon as these arrangements are completed.

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ELECTRIC WELDING.*

BY PROF. ELIHU THOMSON.

About a year and a-half ago I gave a description of the newly-developed art of electric welding, calling attention to the principles underlying its practice, and the results accomplished in the welding of various metals and alloys.

On the present occasion, the purpose is to show the apparatus, or at least a few forms of it, in operation, and to describe the working and construction.

Quite a number of types of apparatus have been developed, some of which are before us, and others we have at our factory at Lynn, Mass.

What we call the indirect, or induction, type takes current of comparatively high potential from a dynamo giving alternating currents, or from any other suitable source, such as a lighting supply line, and converts, or induces, from it a current of very low potential and great volume for electric welding, soldering, brazing and forming of metals. One form of apparatus, which will be used for welding iron and copper wires, is here before you (Fig. 1).

The "direct" type generates the currents needed directly from belt power or mechanical energy, and consists of a specially organised dynamo provided with a set of welding clamps. In fact, the needs of electric welding have given rise to a number of special and somewhat curious types of dynamos, which might not otherwise ever have been invented or constructed. But one of these forms is here shown, a number of others having been designed and constructed, and others again are undergoing construction. Fig. 2 is an example of a type of direct-welding dynamo, similar to the one on the platform, belted to the Institute engine.

The storage battery, properly arranged, constitutes another type. It is charged from a line, or by a small dynamo kept running constantly by power. Since the welding or heavy-discharge currents are only needed at intervals, a comparatively small dynamo will

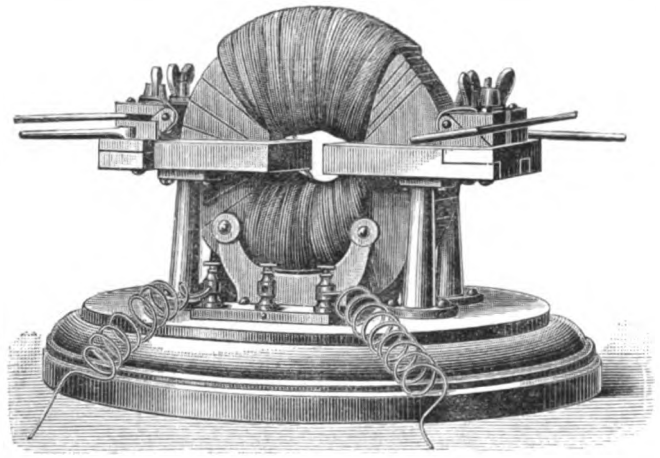

Fig. 1.

usually suffice for the charging. We have used a suitable cell of storage battery quite successfully in electric welding. Even primary batteries may, if of sufficiently low internal resistance, be used for the work, but are comparatively expensive to run.

Variations in the proportion and details, especially of the clamping devices, are made to suit the nature and size of the work to be done, and the shape of the pieces to be handled.

It may be mentioned that for some purposes a combined engine and dynamo for welding may come into use, especially where the work is intermittent. Thus an apparatus in all respects like a steam fire engine, but with a dynamo generating the requisite currents and substituted for the pumps, would be useful where portability is requisite and comparatively heavy work is to be done in isolated localities. The fact that the work is intermittent permits the use of less boiler capacity than would be the case were the plant to be under full load continuously.

I call attention to the numerous examples of work done as exhibited by the specimens which are found on the two sample boards before you, and upon the table. Here is a unique specimen, a shaft with two collars, formed without any welding at all, by simply pressing it endwise by the clamps with the current put on.

Here, again, is a very curious piece, which I am sure could not be produced at all without such apparatus as is shown here. It demonstrates the rapidity with which work can be done, and the localisation of the heating effects.

The specimen referred to is one in which a bar has been put through a hole in a flat piece of wood, and burrs raised on the bar at both sides of the wood, so that the wood is held between the two expansions in the bar, and almost pinched between them. The operation was so quickly done that the heat had not time to char the wood and enlarge the hole; or, if I may be permitted to say it, the wood had not time to find out that it should burn.

Among the specimens here shown are rings, cast-iron pieces, various tools constructed by use of electric welding, chains and links, &c. The various metallic alloys, as brass, German silver, are seen, in addition to heterogeneous welds or welds of different metals one to the other.

Many persons are puzzled to know how a ring can be welded at all by the current, especially such small and thick rings as are here shown, but there is no mystery about it. The current goes by the short path in greatest amount, and so welds the ring. This is particularly true of alternating currents of rather rapid rate, and, in fact, we have organised devices which absolutely prevent more than a small fraction of the current going around the ring. To do this we have only to establish conditions such that a current going around the ring has to produce magnetism in a closed iron core, while that which does the welding is comparatively free from such necessity. In such case, self-induction and resistance are both acting together to prevent flow around the ring instead of across the joint to be made.

Tests of tensile strength of electric welds are eminently satisfactory, and the occasion may some time come when I can present the results, or consider for you electric welding from the standpoint of its perfection as a welding process. Its utility is, however, already established. It does very many things which no other process can do or has done.

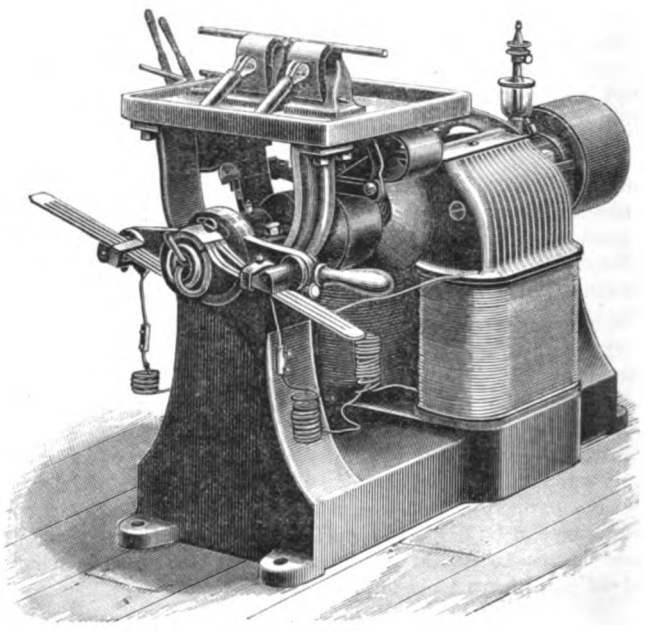

Fig. 2.

Here is a sample of lead pipe, welded without obstruction of its interior, and even without expansion outside. At a short distance away the pipe cannot be distinguished from a plain piece, and its exterior has been left just as it came out of the welding clamps.

Here, again, is a finished axe, with the steel cutting edge welded to the body by electrical means, the welding being the last operation done before final grinding for finish.

Here is a steel rake made by electricity, and several specimens illustrating the making of carpenters' squares by electric welding.

* Abstract of Paper read before the Franklin Institute, September 19th 1888.

ACCOUNT OF A HOUSE STRUCK BY LIGHTNING AT LISBON.

BY W. B. SAYERS.

A heavy thunderstorm broke over Lisbon and the surrounding country on Sunday, the 9th of September, lasting some twelve or thirteen hours. The following is an account of a flash that struck a house, which, by the courtesy of some friends, I had an opportunity of examining after the occurrence. The courses of the discharge through the house were so clearly indicated as to admit of no doubt whatever, so that I have been able to make the sketches (Fig. 1 and Fig. 2) without any undue exercise of the imagination.

The house is the summer resort of Illmo. Exmo. Snr. Carlos Eugino Almeida, and is called Chalet Torrezão. It is situated about eighteen miles west of Lisbon, at a beautiful little seaside

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place called Estoril. The foundations rest on a rocky mound about 100ft. high, close to the sea shore, and in sight of the bar of the Tagus. There was no lightning rod.

Fig. 1 represents a front view of the house, which faces the sea southward. Fig. 2 is a cross-section, showing the paths taken by the discharge. The lightning struck the flag-post, the position of which is indicated at A (Figs. 1 and 2). The post was shivered into splinters, and was blown about over the space in front of the house like so much straw. From the flag-post the discharge passed, part through the window framing of a top floor bed room, indicated at B B in the sketches, and partly over the surface of the wall outside, and through the hole, shown at C, which it made in the said wall, apparently passing next between the floor boards and ceiling. The floor and ceiling in question remained undamaged for a distance of 5ft. from the point of entrance of the discharge, while the remaining distance traversed was burst open—the floor boards upwards, the ceiling boards downwards—precisely as though a gas explosion had taken place between them; but as there is no gas supply to the house this must have been the unaided work of the electric discharge. From D (Fig. 2) the current divided into two branches, while at E a second division took place. Apparently the largest branch was the one which passed through the first-floor front room. The walls and ceiling of this room were marked and smoked in a motley fashion nearly all over, all the marking radiating from the part of the ceiling which was burst down. An iron bedstead stood in the room, the bedding of which was set on fire, and the large hole, F, was situated just

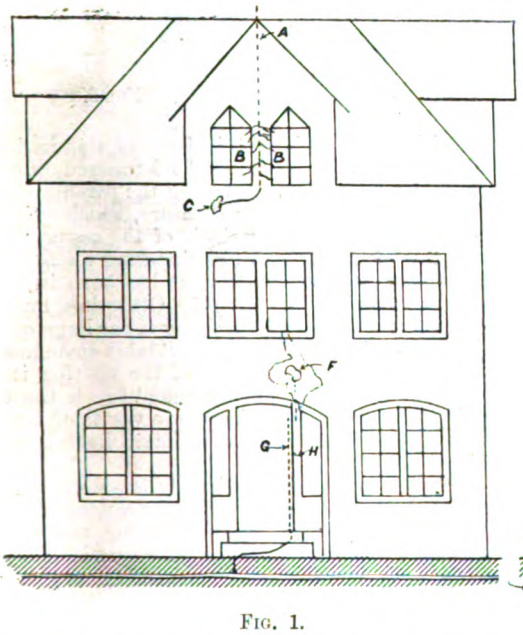

Fig. 1.

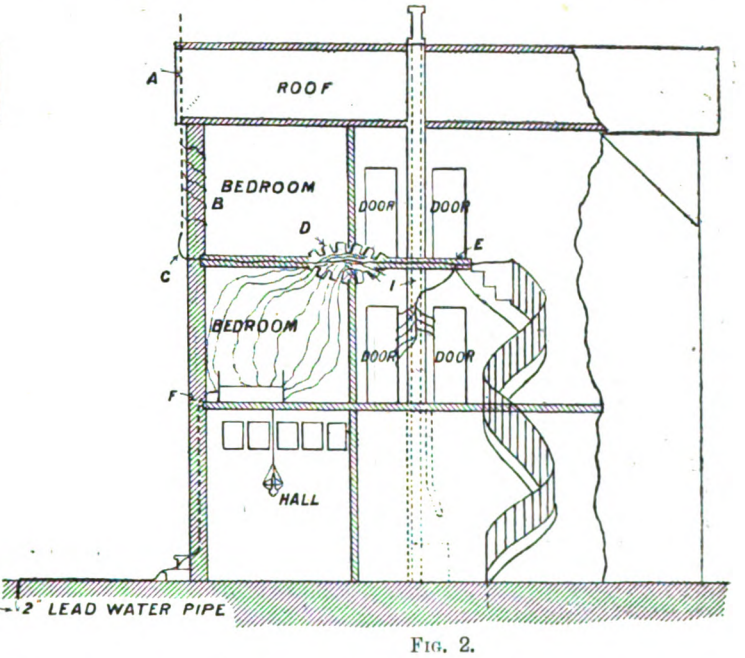

Fig. 2.

opposite one leg of the bedstead. I imagine that this branch must have divided itself out into numerous small branches, which ran more or less generally over the surfaces of the walls, and then leapt to the bedstead, where, gathering into one again, it leapt to the woodwork in the wall, descending by the door post and over two stone steps, and passing over the surface of the ground, a distance of 14ft., it disappeared, making a hole in the ground, at the bottom of which, 15in. from the surface, I found a 2in. lead pipe. The pipe was not in connection with any extended service, being only used to supply water from one part of the grounds to another. The ground in which it lay was damp, and I could find no mark where the discharge had gone to the pipe.

In the course of the passage from the bedstead to the ground were effects of extraordinary violence. The hole in the wall at F was about 2ft. 6in. wide at the widest part, and 3ft. 6in. long, the wall being composed of good stonework. The front door post at G was shattered into splinters, and the door also mangled, as though a steam roller had passed over it. In front of the doorpost stood a rectangular stone column, 6in. by 8½in. in section, shown at H, Fig. 1. This was broken through in the centre and thrown out of position, together with the heavy block on which it stood, and was taken down because unsafe. The corner of one of the stone steps was chipped off, a piece of stone measuring nearly half a cubic foot. From the stone steps to the hole where this branch went to earth there was a black track about 4in. wide, in which everything burnable was scorched up.

The path of the second branch of the discharge is indicated by a hole in the under side of the staircase about 3in. by 5in. (*see* E, Fig. 2), and by a scorched and smoky mark leading to the wall I (Fig. 2), where it divided, five small arms going over the surface of the wall into the room on the left-hand side, and three into the room on the right. About a yard or more inside the doors of the respective rooms the markings ended in conical holes in the plaster from 1in. to 3in. in diameter at the surface, and about equal depths. In nearly all the holes a corner of some piece of wood used in construction of the wall was visible at the apex of the hole, and I concluded at first that this portion of the discharge had found its way to earth through the general mass of the wall. I afterwards discovered, however, that the kitchen chimney, which in Portugal it is customary to make very thin and broad, so as not to thicken the walls, passed through the wall at this point. Some fallen soot on the top of the stove was all there was to be seen of the effects of the discharge in the kitchen below.

The third branch of the discharge which split off from the second at the point marked E (Fig. 2) made for the iron balustrade of the staircase, which is continuous from top to bottom. It passed along 6ft. of plaster partition, ripping the plaster out and baring the laths, and made an "arc" mark where it went on to the iron. A small wooden foot, on which the rail rested at the bottom, was split asunder, and one-half thrown out into the passage.

One thing struck me very forcibly with regard to the damage done to stonework, and that was that, with the exception of the corner which was split off the stone step, it was evidently caused by the violent disruption of woodwork in its vicinity, which must have amounted to a violent explosion. Window frames, door posts, doors, &c., were all torn and shattered in the vicinity of the path of the discharge, while the woodwork which had occupied the main path had disappeared, being literally shattered into straws. Two rows of windows, communicating with the rooms on each side of the hall, had scarcely a sign of glass left in them, and the paraffin lamp, which hung from the centre, was thrown down and broken to pieces.

THE PIEPER ARC LAMP.*

The form of arc lamp originally devised by M. Pieper is shown diagrammatically in Fig. 1. The rod A of the positive carbon holder is very light, and slides in a socket, which allows the lamp to be worked in almost any position. The electro-magnet B, shown vertical for simplicity, is really horizontal. The coils of this magnet are a shunt upon the arc. This magnet acts upon a vibrating armature, C, which is kept in position by the springs R R, and which has a transverse arm, D E, provided at either end with metallic shoes. The projecting piece F makes contact with the stop G at each oscillation, cutting the electro-magnet B out of circuit, and allowing the springs R R to bring back the armature C to its original position. The action of the lamp is as follows:—As soon as the coils of the electro-magnet B are traversed by a strong current, owing to the abnormal resistance of the arc, the armature C is attracted, the shoe D releases the rod A, while the shoe E presses against it and forces it down slightly. The electro-magnet is then cut out of circuit, and the armature takes up its original position. The current then again increases in the coils of B, and the cycle of operations is repeated. This mechanism is

* Translated from M. Hippolyte Fontaine's "Éclairage à l'Électricité," by kind permission of the author.

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therefore nothing more than a small electric motor whose incessant vibrations give a continuous and exceedingly slow motion to the upper carbon holder. A series of screws allow all parts essential to the proper working of the lamp to be regulated as required. The arc is struck, as in the Bréguet lamp, by means of an electro-magnet excited by the main current, and placed under the negative carbon holder. This apparatus works well, but this is due chiefly to the ingenious and careful manner in which its construction is carried out, which shows in every little detail the handiwork of the skilled mechanic.

In his new lamp (Fig. 2) M. Pieper has greatly modified his mechanism. The electro-magnet A A', which is in parallel with the rest of the circuit, has two pair of poles; the external pair tend to revolve, attracted by the armatures N S (Fig. 3), the inside pair clutch the rod of the upper carbon holder. The socket B is fixed to this magnet, and terminates in a threaded portion, which engages in the female screw C. At the top of B there is a cross-piece, which is kept in position by springs. Inside C' there is a

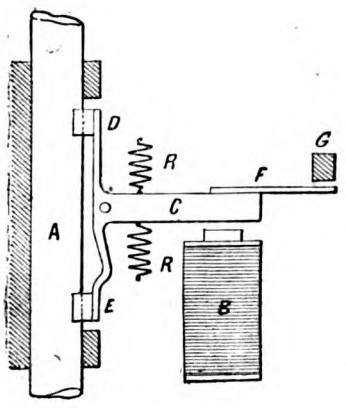
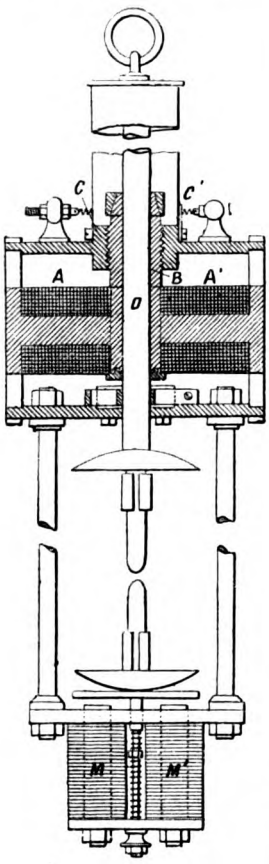
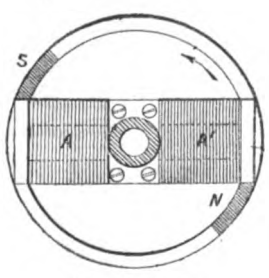


Fig. 1.





Figs. 2 and 3.

contact screw, which periodically cuts the electro-magnet out of circuit when it revolves. The movement of the rod D is controlled so as to prevent it from turning from right to left, or descending by the force of gravity. The arc is struck by the action of the electro-magnet M M'. As the arc lengthens, and the current in the coils A A' increases, the armature attracts the poles, and the magnet turns round from left to right, both B and D participate in this motion, and the carbon feeds down. The electro-magnet is now cut out of circuit by the contact screw, and the springs bring everything, except the rod D, back to its original position. The rod D cannot turn from right to left, and, moreover, it is no longer attracted by the magnet A A'. This action maintains the arc at its proper length as the carbons are consumed. The apparatus is carefully thought out, it is cheap, and works well, provided it is kept in good order. The smallest oxidisation of the rod D interferes with the working of the lamp.

PHYSICAL SOCIETY.

At a meeting of this society, held on Nov. 10, Prof. Reinold, F.R.S., president, in the chair, a Paper was read by Prof. J. A. Fleming,

On a Form of Standard Resistance Coil.

Prof. Fleming stated that he had for some time been endeavouring to devise a form of standard resistance coil which should be free from some of the defects of the ordinary form, shown in Fig. 1, which represents the form of standard coil adapted by the Committee of the British Association in 1865. It consists, as is well known, of a coil of silk-covered paraffined wire, contained in the space between an inner brass cylinder and an outer casing of brass of the form shown in Fig. 1, the ends of the coil being soldered to thick copper conductors as shown, and the space containing the coil being filled up with paraffin.

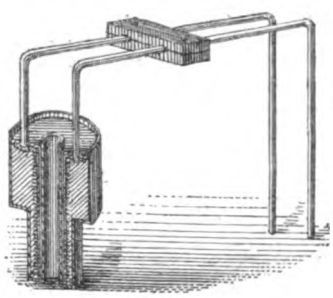


Fig. 1.

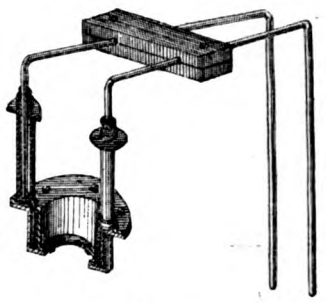


Fig. 2.

The principal objection to which this form of standard coil is open is that the whole of the coil cannot be immersed in melting ice, for if this were done, the upper surface of the paraffin would be cooled to such an extent as to condense moisture, which would produce a short circuit between the terminals of the copper conductors; and though there is not much short-circuiting when the standard is new, it becomes considerable when it has been in use for some time, and the lacquer gets worn off. Other less important defects of this form of standard are that, owing to the large quantity of paraffin, which is a bad conductor of heat, it takes some hours for the coil to assume the exact temperature of the melting ice, and that, owing to the length of the cylinder round which the coil is wound, the melting ice must be contained in a vessel of considerable depth, which makes it difficult to maintain its temperature uniform throughout.

The first attempt to overcome these defects is shown in Fig. 2, and consisted in using a shorter cylinder of larger internal diameter, with a smaller space between it and the outer casing, and enclosing the lower portions of the copper conductors in vertical brass tubes, insulated from them by air, the conductors being supported at each end of the tubes by means of ebonite washers. With this form

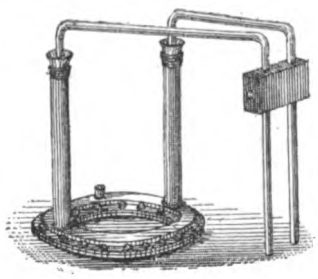


Fig. 3.

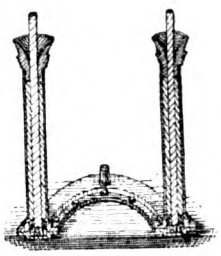


Fig. 4.

the trouble arising from deposition of moisture was diminished, but not entirely obviated. The next step was to still further increase the diameter, and diminish the length of the containing cylinders, and to cover the copper conductors with India-rubber tubes. This form was found satisfactory in every way, except that after a time the India-rubber was found to perish, and no longer protected the conductors.

The form finally adopted is shown in Figs. 3 and 4. In this instrument the coil is wound in a flat spiral, so as to reduce the length of the cylinders to a minimum. The copper conductors are insulated by a layer of air from the vertical tubes surrounding their lower portions, except at the ends of the tube, where a fluid insulator is used. The upper ends of the containing tubes terminate in ebonite cups, which are filled with paraffin oil when the instrument is used, which effectually prevents any creeping of moisture from the tube on to the conductor. The two annular

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discs of brass are provided with flat groves in their opposed portions, and when the annular plates are screwed together the grooves form a closed ring of rectangular section, in which the coil, one or several layers in depth, according to its resistance, is contained. The coil is embedded in paraffin, but a free space is left in the groove of the upper plate. An opening, closed by a screw plug, is made through the upper plate into this groove, and before being used the plug is removed, and air is forced into the core while the instrument is immersed in water, when any defects in the joints will be shown by the air bubbling up through the water. With this flat coil a very shallow vessel can be used to contain the melting ice, and the coil case can itself be made to act as a stirrer by simply moving it up and down in the vessel. Prof. Fleming stated that this form of standard coil, which was exhibited to the meeting, had proved thoroughly satisfactory.

At the same meeting a Paper was read by Prof. J. V. JONES,

On the Coefficient of Mutual Induction of a Helix and a Coaxial Circle.

The author stated that he had recently been making a re-determination by Lorenz's method of the absolute unit of resistance. He had therefore had occasion to consider the best form of standard coil to be employed, and as the use of a single layer of wire presents considerable advantages he decided to replace the form of coil usually employed, consisting of several layers of wire wound upon a very short cylinder, by a single layer wound upon a longer cylinder. The treatment of the coil as a current sheet when the calculation is carried only to a first approximation, as, for example, in Lord Rayleigh's calculations, did not appear to be sufficiently accurate when applied to the coil and helix actually employed to enable a final result of the accuracy arrived at, namely, 1 in 10,000, to be obtained; and the author thought it would prove simpler, and also give a more reliable result, to calculate the coefficient of mutual induction between the coil and helix directly instead of carrying the current sheet method to a second approximation.

The helix employed consisted of silk-covered and paraffined wire one-fiftieth of an inch in diameter, wound upon a cylinder 22in. in diameter and 4in. in length, the wire being wound in a screw thread having a pitch of one-fortieth of an inch cut in the cylinder.

A method of calculation is given considering the wire as a helix whose equations are $y' = A\cos\theta'$, $z' = A\sin\theta'$, and $x' = k\theta$, those of the circle being $y = a\cos\theta$, and $z = a\sin\theta$. The general expression for M, viz., $\iint \frac{\cos\varepsilon}{r}\,ds\,ds'$, when applied to this case becomes

$$M = \int_0^{2\pi}\int_0^{\Theta} \frac{-\Theta A a \cos(\theta' - \theta)\,d\theta\,d\theta'}{\sqrt{A^2 + a^2 - 2Aa\cos(\theta - \theta') + k^2\theta'^2}},$$

where Θ is the total angle of the helix. An integration is performed by change of variables, making $\theta - \theta' = \phi'$ and $\theta' = \phi$. When Θ is an integral multiple of π (say n), the integral is expressible in terms of a series, involving the complete elliptic integrals E and F of modulus $c = \frac{\sqrt{4Aa}}{A+a}$, the expression for M being

$$M = 4n\pi\,\frac{Aa}{A+a}\,\Sigma(-1)^m \frac{1.3\ldots 2m-1}{2.4\ldots 2m}\,\frac{1}{2m+1}\left(\frac{x}{A+a}\right)^{2m} P_m,$$

where $x = kn\pi$,

and $$P_m = \int_0^{\frac{\pi}{2}} \frac{\cos 2\phi\,d\phi}{(1 - c^2\sin^2\phi)^{\frac{2m+1}{2}}}.$$

If $$Q_m = \int_0^{\frac{\pi}{2}} \frac{d\phi}{(1 - c^2\sin^2\phi)^{\frac{2m+1}{2}}},$$

then $$P_m = \left(1 - \frac{2}{c^2}\right)Q_m + \frac{2}{c^2}Q_{m-1} \quad \ldots \quad (B)$$

and $$Q_m = Q_{m-1} + \frac{c}{2m-1}\,\frac{d}{dc}\,Q_{m-1} \quad \ldots \quad (C)$$

Observing that $Q_0 = F(c)$ and $Q_{-1} = E(c)$, P_1, P_2, P_3 may be expressed in terms of $F(c)$, $E(c)$, and c.

Instead of calculating each term P_m independently, it is found easier in practice to deduce the successive values from equations (B) and (C), combined with $(1 - c^2)\,Q_1 = E$ and its derivatives.

The series obtained in this manner were found to be very convenient for the purposes of calculation. The author has compared the result obtained by his method with that obtained by Lord Rayleigh's approximation formula in the case of a helix of radius 10 inches, and an axial length of 4 inches, and a coaxial circle of radius 5 inches in its mean plane, and he finds by his own method,

$$M = n \times 53{\cdot}259,$$

and by Lord Rayleigh's method,

$$M = n \times 53{\cdot}317,$$

a difference of nearly one part in a thousand, which is therefore of importance.

Prof. PERRY observed that practical formulæ of the nature obtained by the author were of great value to electrical engineers. He inquired whether the author had made any attempt to obtain formulæ in which the thickness of the wire was taken into account, the current being assumed to be uniformly distributed through it. He also observed that, as far as he was aware, no one had yet obtained a practical formula for the strength of the field of a cylindrical coil, except for points at a considerable distance, or one which would give the coefficient of mutual induction between two coaxial cylindrical coils.

Prof. FLEMING stated that he had for some time been endeavouring to construct a standard of mutual induction, and the method which he adopted was to wind a coil of insulated wire upon a wooden tore or anchor ring of circular section, the wire being wound uniformly upon it, forming a coil similar to a Gramme ring. Then, if a secondary coil was wound over a portion of this ring, the coefficient of mutual induction was to a first approximation independent of the winding of the secondary coil. This arrangement formed a sort of condenser, and he had used it to check condenser measurements, the method adopted being to insert a ballistic galvanometer in the circuit of the secondary coil, and then to connect the ends of the primary coil to the terminals of a battery and suddenly reverse, observing the swing of the galvanometer.

The AUTHOR, in reply to Prof. Perry's question, stated that he had not investigated the effect of the thickness of the wire, as in the case of the coil and helix which he was using he was confident that this correction would not be as much as 1 part in 10,000. For the same reason he had not hesitated to use silk-covered wire in spite of the slight unevenness in the silk which, was unavoidable. The ideal standard would be a coil of wire covered only with a uniform layer of paraffin wound in a screw-thread. The paraffin would not undergo any sensible deformation for a very long time.

He stated that he had not carried out the calculation of the coefficient of mutual induction of a circular coil and a coaxial cylindrical helix to a second approximation, on the assumption that the helix was equivalent to a current sheet. If this were done the result would, no doubt, agree more closely with that obtained by his method, but the calculations would be much more complicated than those involved in the direct calculation. With regard to Prof. Fleming's anchor ring, he did not think it would be as good a form for a standard as a cylindrical coil wound upon a screw thread, as it would be very difficult to wind the wire uniformly upon the ring.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, November 24th.

PHYSICAL SOCIETY.

8 p.m. "On the Measurement of the Luminosity of Coloured Surfaces." By Capt. ABNEY, R.E., F.R.S.
"On the Suppressed Dimensions of Physical Quantities." By Prof. RÜCKER, F.R.S.

MONDAY, November 26th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. "Light and Colour." By Capt. W. de W. ABNEY, C.B., F.R.S.

TUESDAY, November 27th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "The Witham New Outfall Channel and Improvement Works." By J. EVELYN WILLIAMS, M.I.C.E.

WEDNESDAY, November 28th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Phonograph." Col. GOURAUD.

FRIDAY, November 30th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "The Covered Service-Reservoir of the Southampton Corporation." By E. T. HILDRED, Stud. Inst. C.E. "On the New High-Level Storage Reservoir for the Grand Junction Waterworks Company at Hanger Hill, Ealing." By H. ASHLEY, Stud. Inst. C.E.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received.

CONTENTS OF THE CURRENT NUMBER.

Notes	65	Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued	78
Lightning Conductors. — III. By Dr. Oliver Lodge. Continued	70	The Society of Telegraph Engineers and Electricians—	
The Grosvenor Gallery Central Lighting Station.—II. Illus.	71	On a System of Electrical Distribution. By H. Edmunds. Illustrated	80
Electric Welding. By Prof. Elihu Thomson. Illustrated	72	Supplements—	
Account of a House Struck by Lightning at Lisbon. By W. B. Sayers. Illustrated	72	The South African Cables	82
The Pieper Arc Lamp. Illus.	73	The Electric Light at Souakin	82
Physical Society—		American Notes	82
On a Form of Standard Resistance Coil. Illustrated.	74	Correspondence. Illustrated	83
On the Coefficient of Mutual Induction of a Helix and a Coaxial Circle	75	Companies' Meetings, &c.—	
Meetings of Scientific Societies.	75	Eastern Telegraph Company.	88
Central Station Lighting and the Board of Trade	76	South of England Telephone Company	89
Researches in Atmospheric Electricity. By Prof. Leonhard Weber, of Breslau. Illus.	77	Pacific Cable Conference	89
		The Pacific Telegraph Scheme	91
		Patent Record	91
		New Companies Registered	93
		City Notes, &c.	93
		Companies' Share List	94

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CENTRAL STATION LIGHTING AND THE BOARD OF TRADE.

The publication of the Kensington Court (Draft) License (*The Electrician*, Nov. 9th, p. 13) has served to direct attention afresh to the powers possessed by the Board of Trade under the Electric Lighting Act of 1882 and the Amendment Act of the present year. A careful study of these powers further results in affording additional evidence of the need for an organisation such as that which the electrical trades have just established under the auspices of the London Chamber of Commerce. It is, indeed, hardly too much to say that the Board of Trade is practically at liberty to frame whatsoever conditions it may see fit, within the general scope of the Acts, for the guidance, control and supervision of electric lighting

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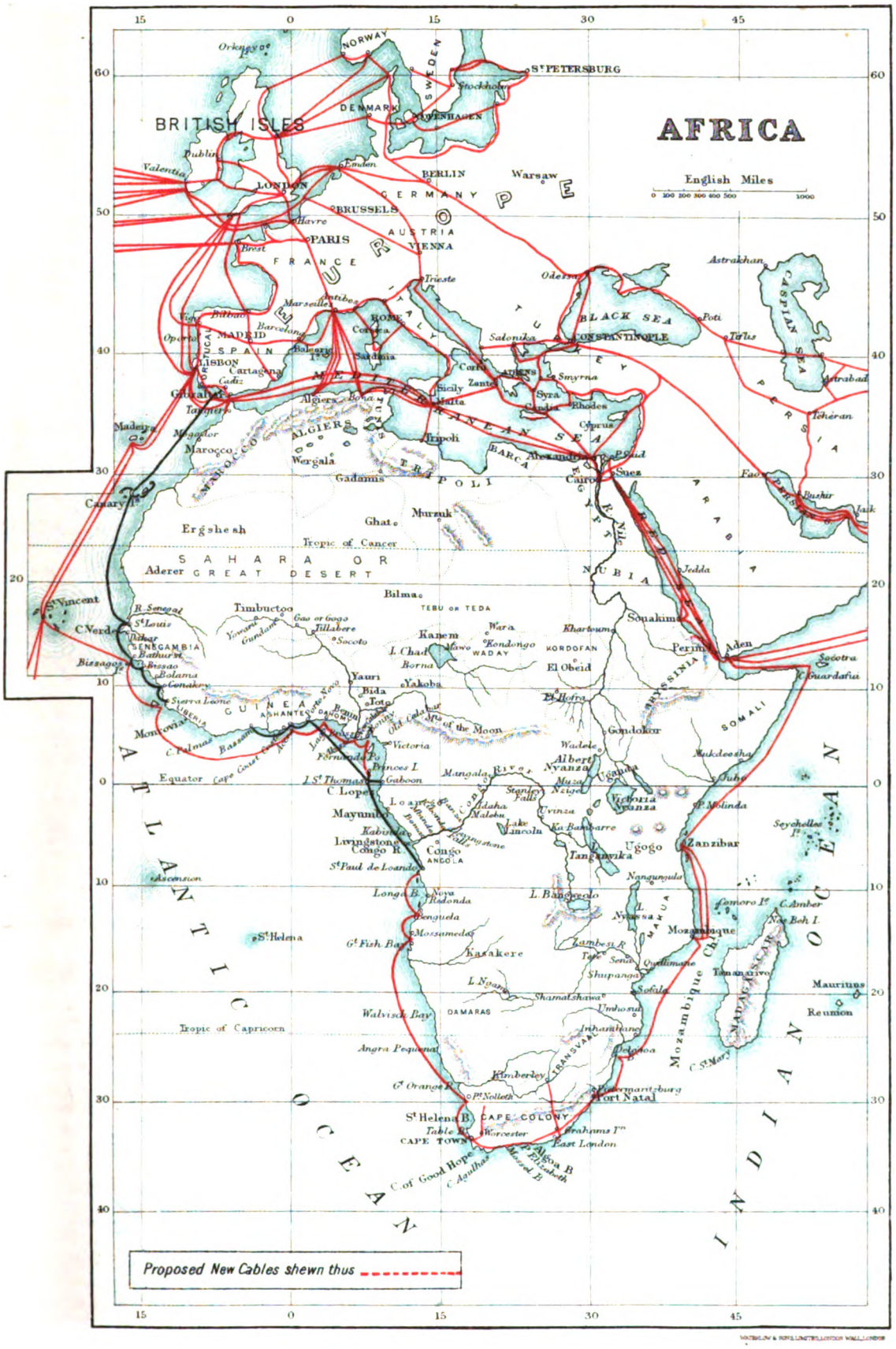

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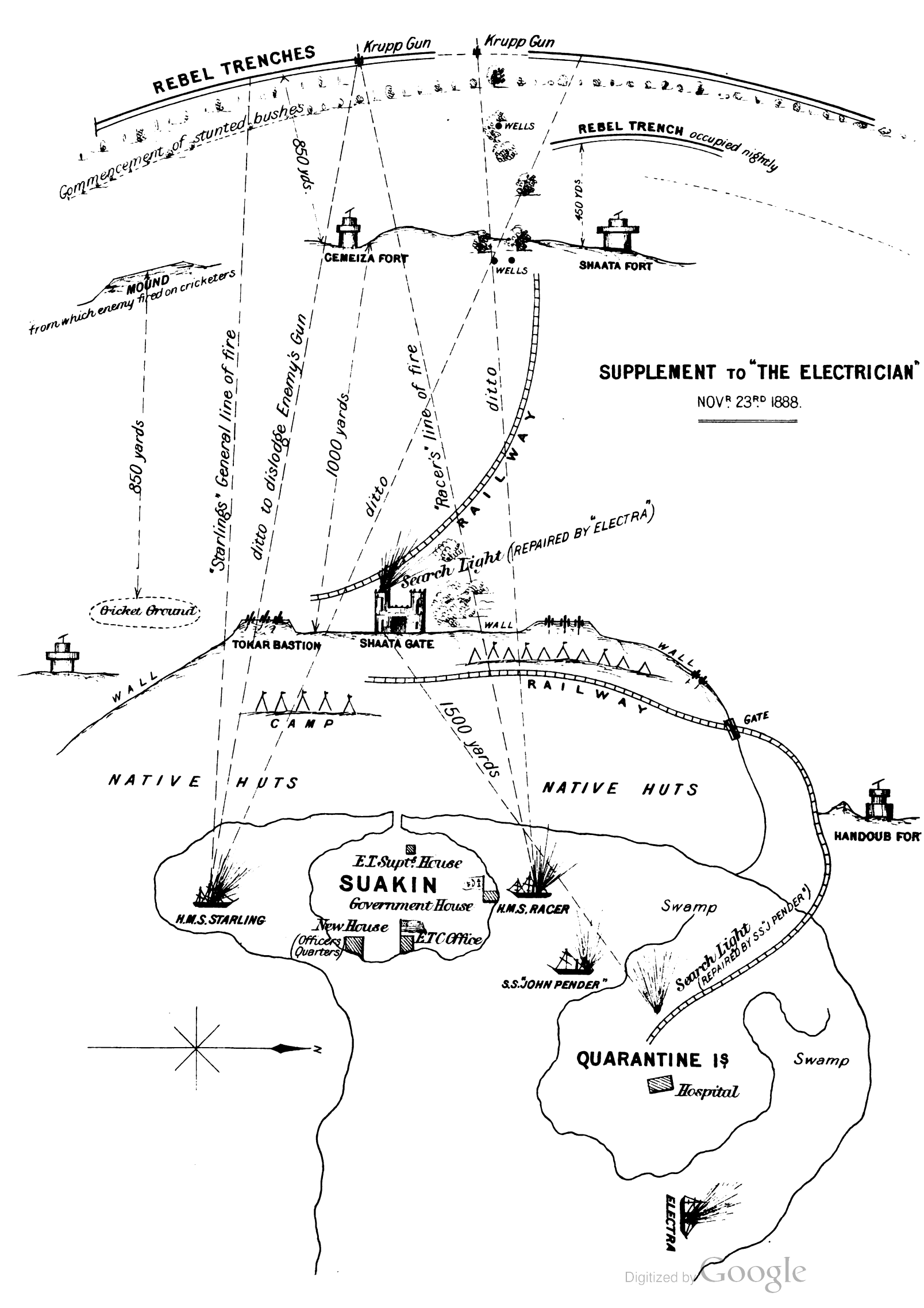

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undertakers, whether under provisional orders or licenses. In these circumstances one of the first duties of the undertakers is on their part to endeavour to induce the BOARD OF TRADE to promulgate only such Regulations as will be generally acceptable to the electrical trades; and to this end it is obvious that an interchange of views, now rendered practicable by meetings at the CHAMBER, and a common understanding, will be of the utmost practical value.

Fortunately the case is not one of dogmatism and obstruction on the one hand, or laxity and exaction on the other. The undertakers desire only such reasonable latitude as experience and foresight would seem to warrant; and it is fair to admit that the BOARD OF TRADE has shown no disposition to hamper them by impossible conditions. The Kensington Regulations, some at least of which might be cited to the contrary, are, it is understood, of a tentative character, and are put forward to ascertain what kind of reception they will meet with. We have already pointed out some inconsistency in their wording leading to contradictory inferences which could hardly have been the work of a legal draftsman. It cannot be doubted that a representation from the trades concerned will, for example, result in making perfectly clear in any future issue to what extent, if at all, the undertakers are responsible for work which they have had no hand in performing. Met with moderation the Board will, we feel sure, give a respectful consideration to these and other points of difficulty which may be discovered and laid before it in respect to the administration of the Act.

We also feel satisfied that the manner in which the Electrical Trades Section has already entered upon a discussion of this and other cognate matters will conduce to good progress being made under the Act as now amended. To begin with, we learn that the Section is virtually agreed as regards certain points on which the interests of its members are not identical, and which, consequently, will not form the subject of joint representation to the BOARD OF TRADE or the Local Authorities. If this be the case, one of the chief preliminary obstacles to the smooth working of any trade organisation has been speedily overcome.

Having disposed of this internal difficulty, the Section has given its earliest attention to a subject of immediate practical importance. The BOARD OF TRADE is to be asked to alter the definition of the unit from 1,000 watt-hours to 10,000 watt-hours; the object of the change being to enable the price of a unit to be quoted within narrower limits. Under any definition an alteration of one farthing is practically the smallest change of price which can be effected; and under the BOARD OF TRADE'S standard this would usually amount to somewhere between two and three per cent. of the total charge. Upon a large scale of working it is evident that a more minute scale of adjustment will be desirable, and this can easily be effected by the proposed change in the definition of the unit.

Of even greater importance, but not so easy of solution, is the question arising out of the wiring the consumers' premises in the district in which the supply of electricity is compulsory. We have already alluded to the responsibility involved under these conditions. For the safety of the system as a whole, the undertaker ought certainly to have some guarantee that the wiring and fittings indoors have been properly done, since the consequence of a defect in these details may not always be confined to the premises on which it occurs. Where the undertakers *only* supply current the difficulty may perhaps be met by conferring upon them the right to inspect the fittings before current is turned on; but in cases where the Supply company contract for internal installation as well, it would be impossible to confer the right to reject the work of an outside firm without giving rise to much heartburning. On the other hand, it would not be fair, even if it were practicable, to prevent customers employing what firms they please to contract for the wiring and fitting. The LONDON ELECTRIC SUPPLY COMPANY have, we believe, experienced inconvenience and incurred some odium in this connection. A remedy agreeable to all parties is not yet ready to hand, there being only a general agreement at present that a multiplication of such functionaries as Mr. HEAPHY would, to say the least of it, be a *pis-aller*.

Concurrent action, however, on the part of the Electric Supply companies is advisable not only in relation with the BOARD OF TRADE, but also, and perhaps even more imperatively, with the Local Authorities. The need for this is forcibly exemplified by recent proceedings at the Kensington Vestry. Here the representatives of several companies were, it is said, successively interviewed, with the avowed object of seeing which would yield the most, particularly in respect of the compulsory purchase clause. Now, competition, in the usual commercial sense of the word, should be as unrestricted for electric lighting as for all other kinds of contracts, and we should be the last to countenance any suggestion to the contrary; but we do take exception to that form of competition which seeks to gain its end by contracting itself outside an Act of Parliament which is supposed to be binding upon all the competitors. In matters of tariff let there be an open market, but in respect of the compulsory purchase clause we think it most desirable that undertakers should stand loyally by the Act. In saying this we do not, of course, suggest that undertakers shall bind themselves beforehand not to sell until the expiry of forty-two years—that would be an absurd suggestion; all we mean is that no pledge on the subject ought to be given to the local authorities for the purpose of inducing them to adopt one system rather than another. To do so would be to stultify the work of those to whom the Amendment Act of 1888 has been due, besides being a gratuitously suicidal act on the part of the contractor.

RESEARCHES IN ATMOSPHERIC ELECTRICITY.*

BY PROF. LEONHARD WEBER, OF BRESLAU.

The experiments described in this Paper are a continuation of those undertaken at the request of the German Electrotechnic Union, and a preliminary report of them has already been published.† The present experiments were communicated to the (German) Committee for considering Danger from Lightning.

The first part of the Paper gives details of the erection of two experimental lightning rods on the summit of the Schneekoppe, one of the chain of Riesengebirge, and situate about 80 miles S.W. of Breslau. The common base of the two rods was a square of three metres side, and at each of its corners a wooden trestle was erected whose construction will be understood from the figure. The two vertical pieces are sunk to a depth of about ¾ metre into the hard rocky earth, and carry two horizontal cross-pieces. Between these latter rests the end of a wooden beam Q, insulated from them by the two glass cylinders A A′, each about 10 centimetres long and 7 centimetres diameter. The cylinders are kept dry by sulphuric acid surrounding them, and contained in the covered pans x x. The beam is clamped in position by an iron screw pressing on a piece of wood which rests on the upper glass cylinder. The two wooden beams Q support a single beam about 6 metres long, running at right angles to themselves and fastened to them by bolts. At the points of junction of these beams the two lightning rods were erected. Each is held in position by four iron supports, and also by three galvanised iron wires attached to the ends of the beams, which can be tightened up in the same way as the supporting wires of an ordinary telegraph post. The conductors are thus parallel, three metres apart and about 15½ metres high. They are tubular, and taper like a fishing rod, the diameter at the base being 7 centimetres and at the summit 1½ centimetre. On the top of each is a gilt sphere of 8 centimetres diameter. Just below this sphere is fixed an iron ring, by means of which any apparatus,

* Abstracted from *Electrotechnischer Zeitschrift*, April, 1888, by Dr. J. L. Howard.

† *Electrotechnischer Zeitschrift*, Bd. VIII., Heft 11, Nov., 1886.

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such as slow matches or needle points, can be hoisted to the top for purposes of experiment.

To one of the four supports holding the rod is attached a metallic knob. Opposite, at an adjustable distance, is placed a second knob connected to a bent iron rod, one end of which is buried in the earth with the trestle. This rod also has a wire leading off to the network of earth wires belonging to the telegraph posts on the mountain. The author mentions the advisability of connecting the knobs by a fusible cut-out in order to tell, in case the rods are struck, which one has conducted the discharge, but he does not say that such cut-outs were actually used.

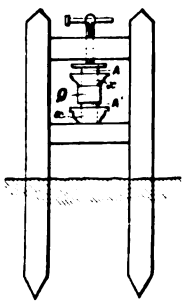
It is worthy of notice that since the rods were set up (*i.e.*, during the whole of the past year) *no lightning discharge whatever* has struck the mountain. Before their erection it was very frequently, indeed almost regularly, struck by lightning; consequently no results obtained with these rods can be given as yet.

The second part of the Paper is a discussion of the distribution of electricity on an insulated vertical conductor, when the potential of the air is assumed to fall at a constant rate as we ascend from the earth's surface. The object of this portion of the communication is to obtain a relation between the electrostatic potential of the conductor and the potential of the air at the upper end of it. If V_h be the potential of the air at the upper end of the conductor, and W_h that of the electricity induced on the conductor by the atmospheric potential V_h, we have, for the potential U of the rod,

$$U = \text{constant} = V_h + W_h = V_u + W_u,$$

where the suffix u refers to the lower end of the rod. If the fall of potential is constant $W_h = -W_u$, and, hence, $W_u = -\frac{V_h - V_u}{2}$.

We can regard the layer of air in contact with the earth as being at zero potential—*i.e.*, $V_u = 0$ in all cases. This gives us $U = \frac{1}{2} V_h$ and $W_h = -\frac{1}{2} V_h$. If the lower* end of the conductor be momentarily put to earth we get a different distribution—namely, $U = 0$, $W_u = 0$, $W_h = -V_h$.



The case of a conductor bearing a point or flame at one end is then considered. The term "aspiration" is used by the author to denote the action of such points or flames. The author shows that in the case of a conductor with strong aspiration at its upper end, and a similar weaker effect acting along its entire length, the potential of the conductor will be a little less than that of the air at its upper end, or $U < V_h$. Hence the insulated conductor ought to have nearly twice as high a potential when a flame burns at its upper end as it possesses when no aspirating apparatus is used, assuming always that the potential of the air falls at a constant rate on ascending from the earth's surface. Experiment always showed that the flame raises the potential of the conductor from 10 to 20 fold in the case of lightning rods such as those previously described. The author thinks that this discrepancy throws doubt upon the ordinary theory of the action of flames, and inclines to the belief that burning a flame at the end of a conductor is equivalent to increasing its length, the flame sucking down, as it were, the equipotential surfaces above it.

The rest of the communication contains a report of experiments with kites and balloons, to which long metallic wires were attached. Measurements were made of the strength of the current passing between these wires and the earth through a galvanometer. If the aspiration took place wholly at the upper end of the conductor—for example, by needles on the kite or balloon—the current would be proportional simply to U_h; but with an aspiration along the entire length (which always showed itself in the experiments) as well as that at the upper end, we have $J = \frac{1}{\sin\phi} \int_l^h V_x \alpha \, dx + A V_h$, where J is the current strength, ϕ the angle made by the metallic wire with the horizon, h the vertical height of the kite or balloon, and V_x the air potential at a vertical height x. A and α are constants depending on the rate at which aspiration takes place at the upper end of the wire and along its length respectively. Differentiating the equation, we obtain $\frac{dJ}{dh} = \frac{1}{\sin\phi} \alpha V_h + A \frac{dV_h}{dh}$, and, if a curve be made with the current strengths as ordinates and the vertical heights of the upper end (h) as abscissæ, we shall know that when the curve is convex to the axis of h the potential of the air falls at a constant or increasing rate as we go upwards from the earth's surface.

The wire used consisted of steel wires each of 0·27mm. diameter stranded together, and its weight was 32grms. per metre. The same wire was used with both kite and balloon. Its total length was 600 metres, and the length in use at any time was measured by means of coloured silk threads placed on the wire at distances of 10 metres apart. The largest current obtained in the experiments was about $9{\cdot}2 \times 10^{-6}$ amperes.

The results show that the rate of fall of potential generally increases with the height; but clouds have a very great influence upon the electrical distribution in the air. Cirrus clouds generally increase, and cumulostratus clouds decrease, the rate of fall of potential. When the clouds pass over the original distribution is restored. Rain tends very strongly to equalise the potential of the different layers of the atmosphere.

Some experiments made during a thunderstorm on an insulated lightning rod belonging to the University of Breslau are described at the end of the paper. The rod was connected to earth through a sensitive dead-beat galvanometer, and indicated a constant current from lightning rod to earth; this current was interrupted at every flash by a sudden kick generally in the opposite direction to the constant current, but sometimes in the same direction. No explanation of these phenomena has yet been discovered.

* The author considers the case of the upper end of the conductor being put to earth, and puts $W_h = 0$; but this is apparently an error of his. Whatever part of the conductor be put to earth we must obtain the same condition, $U = 0$.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section II.—Electro-Magnetic Fields.

(*Continued from page 45.*)

We may put the facts which were explained in our last paper very concisely in algebraical form by saying the magnetising force produced by a coil is proportional to

$$\text{Current} \times \frac{\text{total wire length}}{\text{coil diameter} \times \text{coil length}};$$

or the same law may be expressed in C.G.S. units by derivation from that already given in para. 130, viz.:—

$$\text{Magnetising force in C.G.S. units} = \frac{\text{ampere-turns}}{\text{coil length (centimetres)}} \times 1{\cdot}257,$$

where the constant 1·257 is the ratio $\frac{4\pi}{10}$, as explained in that paragraph. For, the number of turns in any coil is equal to the total length of wire, divided by the mean length per turn, and the mean length per turn is equal to the mean diameter of the coil multiplied by π (3·1416).

Therefore, cancelling out the constant π, we may write the above in the form

$$\text{Magnetising force in C.G.S. units} = \text{Amperes} \times \frac{\text{total wire length}}{\text{coil length} \times \text{coil diameter}} \times \frac{4}{10},$$

all measurements of length being in centimetres. From this it is clear that it is only when the *mean surface* of different size cylindrical coils is the same that we can compare the strengths of field produced by each by the product of the current and the length of wire; in other words, by the number of ampere-feet on each.

To return, however, to the magnetisation test. The number of turns per foot was 222·5, and the magnetising force was, therefore,

$$\text{Amperes} \times 222{\cdot}5,$$
$$= \cdot 18 \frac{D}{P} \times 222{\cdot}5 \text{ ampere-turns per foot.}$$

Reducing all galvanometer deflections (D) to position 32 (P = 32), as in the last example, and multiplying up, we have

$$\text{Ampere-turns per foot} = 1\tfrac{1}{4} D;$$

all that was necessary, therefore, was to add on to each deflection (reduced to 32) one-quarter of its value. These results

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give the magnetising forces in ampere-turns per foot, due to the current in the coil; but we have an additional magnetising force constantly acting on the core, which must be taken account of. The core being vertical is acted upon by the vertical component of the earth's field. Taking the Kew Observatory data given in para. 110, and calculating out the value of the above, we have

Earth's vertical field = H × tangent of angle of dip.

The angle of dip or inclination is 67° 37′, and its tangent = 2·4282. Therefore

Vertical field = ·1810 × 2·4282 = ·4394 C.-G.-S. units.

This must be expressed in ampere-turns per foot, in order to add it to the magnetising forces due to the coil. We can do this from the expression

Field in C.-G.-S. units = 1·257 × ampere-turns per centimetre.

Now, 1 foot = 30·48 centimetres, and therefore the number of ampere-turns per centimetre is equal to

$$\frac{\text{ampere-turns per foot}}{30{\cdot}48}.$$

Substituting this value, and dividing out, we have

Ampere-turns per foot = field in C.-G.-S. units × $24\frac{1}{4}$.

The vertical force of the earth is, therefore, in this latitude equal to a magnetising force of

·4394 × $24\frac{1}{4}$ = 10·66 ampere-turns per foot,

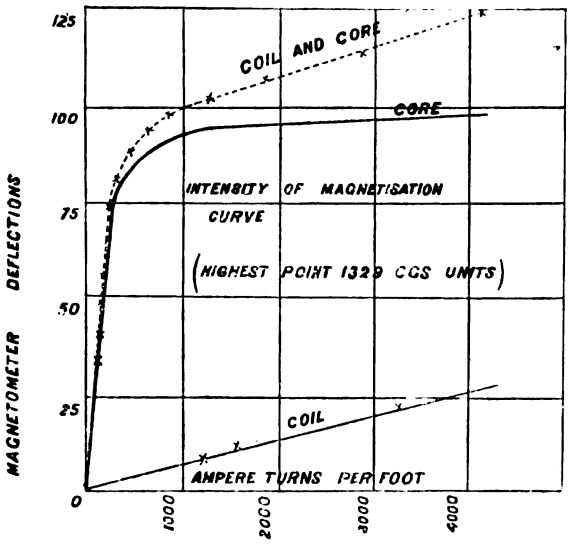

Fig. 118.

and is added to the magnetising forces set up by the coil to give the total magnetising force. We say *added*, because the current was purposely passed round the coil in the direction to cause the lower end of the core to become a north pole, and the earth's vertical force has the same effect. Had the current been in the other direction, the earth's force would have been subtracted. The usual method of dealing with this force is to neutralise it by winding another coil outside the first coil. This extra coil is usually of fine wire, and a current is passed through it just sufficient to set up a field exactly equal and opposite to that of the earth, and this current is kept on continuously during the magnetisation test, neutralising the vertical field.

The iron core, which was mechanically very soft and carefully annealed, was 90 centimetres long and 2·6 millimetres diameter. The length was, therefore, 346 times the diameter, and over Prof. Ewing's minimum limit for negligible demagnetising effect. In consequence of this it will be noticed that the rise in magnetisation is much more rapid at the commencement of the curve (Fig. 118) than with the former short iron core. The vertical ordinates of the two curves do not allow of comparison, since the cores are of different dimensions. This comparison must be made by the intensity of magnetisation, which can be calculated by the formula stated above. We must first find the value of m.

The distance (r) of the upper pole from the needle was 20 centimetres, and the length (l) of core being known (90 centimetres), the distance (R) of the lower pole can be found by

$$R = \sqrt{r^2 + l^2},$$

R being the hypothenuse of a right-angle triangle, of which r and l are the two other sides ("Euclid," I., 47). Working out these values we get for the denominator of the above expression ·9898, and for the numerator 72 tan a. We have, therefore, $m = 72{\cdot}73 \tan a$.

Now the sectional area of core is equal to

$$\frac{\pi d^2}{4} = {\cdot}7854 \times ({\cdot}26)^2 = {\cdot}053 \text{ sq. cms.},$$

and therefore the intensity of magnetisation is equal to

$$\frac{m}{a} = \frac{72{\cdot}73 \tan a}{{\cdot}053} = 1{,}370 \tan a.$$

We can now find the magnetisation at any given point on the curve. Take the highest point, viz., 97 divisions:—

I = 1,370 × ·97 = 1,329 C.-G.-S. units.

On switching off the current the magnetometer remained steady at 45 divisions; hence the residual magnetisation was

1,370 × ·45 = 616 C.-G.-S. units,

or 46 per cent. of the maximum magnetisation acquired. When the current is suddenly interrupted in this manner the residual magnetism is not so great as when the current is gradually reduced to zero. In soft annealed iron wires, whose relation between length and diameter was similar to the above, Prof. Ewing found the residual magnetism some 85 per cent. of the maximum; and as much as 90 and 93 per cent. in other specimens of soft iron ("Researches in Magnetism," *Phil. Trans.*, 1885).

136. *Comparison of Magnetisation Curves.*—The two curves obtained have been plotted with magnetometer deflections as

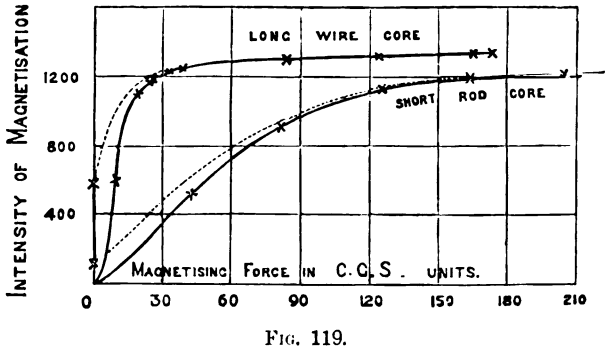

Fig. 119.

ordinates, but they cannot be compared by these deflections, as they were taken by different methods and with cores of different sectional area. We shall now compare them by plotting them with the intensities of magnetisation as ordinates, and at the same time express the magnetising force in C.-G.-S. units instead of ampere-turns per foot. For every 1,000 ampere-turns per foot we have 41·24 C.-G.-S. units (para. 134), and by inspection of each curve we find the magnetometer reading (tan a) corresponding to each 1,000 ampere-turns per foot and intermediate points. The intensity of magnetisation is derived from the magnetometer reading by

$$I = 1086 \tan a$$

in the first curve (para. 134), and by

$$I = 1370 \tan a$$

in the latter.

For example, in the latter curve we find by inspection that for 1,000 ampere-turns per foot (equal to 41·24 C.-G.-S. units) the deflection is 92, and therefore the magnetisation is 1370 × ·92 = 1260 C.-G.-S. units. Similarly, for 400 ampere turns per foot (equal to 16·5 C.-G.-S. units) the deflection is 80 and the magnetisation 1370 × ·8 = 1096 C.-G.-S. units. Taking several points this way, and plotting them as in Fig. 119, we are able to observe the relative magnetisation of the two cores. The main

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points of comparison are the relative magnetisations acquired under any given magnetising force and the magnetic "retentiveness" of each core. It should be borne in mind that the top curve is that taken with a core whose dimensions satisfy the condition of "endlessness," and is a soft annealed wire, while the lower curve is that from a short iron rod of soft iron, but unannealed. The marked difference in the rise of the two curves is partly due to the slightly different nature of the iron, but *chiefly* due to the dimensions of the cores. This is very clearly shown by Prof. Ewing (to whose results the above are similar) in his experiments. He cut from the *same piece* of iron wire (of 1·8 millimetre diameter) different lengths, whose ratios of length to diameter varied from 50 to 300. The demagnetising effect and slow magnetisation were therefore proved to be due to the ends in short lengths.

In the above there was practically no demagnetising effect set up by the poles of the long wire core, and hence the full magnetising force of the coil could take effect upon it. With the short rod core, however, the poles caused a considerable reverse field of force, through the metal (para. 133) neutralising part of the field of the magnetising coil, and preventing the iron from becoming magnetised. This accounts for the very little residual magnetism left, being only about 9 per cent. of the maximum, for, when the current in the coil was reduced to zero the poles of the core exerted their reverse field, tending to neutralise the magnetism acquired. On the other hand, with the long wire core the poles could exert no demagnetising effect, and hence the iron, though softer, retained a much greater percentage of magnetism. These facts indicate clearly that magnetisation and residual magnetism depend as much on the shape as on the kind of iron. While it is always best to use soft iron to obtain the highest magnetisation for a given magnetising force, it is advisable in the construction of electro-magnets where the residual magnetism is to be minimised to make the core short and thick rather than long and thin. The cores of electro-magnets of fast-speed telegraph instruments have of late years been constructed more of the "squat" shape, this having been found to allow of more rapid signalling than the original tall, thin cores.

(To be continued.)

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society held yesterday (Thursday) evening, November 22, at the Institute of Civil Engineers, the President, Mr. E. Graves, in the chair, the following Paper was read:—

On a System of Electrical Distribution.

BY H. EDMUNDS.

It has been remarked that it is undesirable to bring a Paper of this kind before a scientific society on a subject which is only in its initial or untried stage. While there may be some justice in this remark, I think that in bringing this Paper before this Society to-night, I may have the opportunity of laying before you the results of certain experiments and actual work now extending over some 10 or 12 months, and of pointing out to you what have been the results of that work, and what the indications are with regard to its usefulness and extension.

In designing this system of Central Station Lighting it has been my endeavour to develop a plan of effectively and economically distributing the electric light over a given area, which should practically isolate each installation and make it independent and self-contained; which should obviate the use of objectionable machinery on the consumer's premises; which should ensure freedom from powerful and dangerous currents of electricity; which should provide a reliable supply of the electric current at all hours of the day or night; and which would enable a simple and readily understood form of meter to be used that would command the confidence of the consumer.

One of the great desiderata of a system of lighting is constant supply. It is not sufficient to supply the illuminant for a specified number of hours per day; what the householder wishes to have is a means by which he has always at hand a reliable source of light, capable of supplying all his requirements night and day. To ensure this it would be necessary either to have the generating machinery always at work during the whole twenty-four hours, or to employ some system of storage. Even if the machinery were constantly kept running, however, that would not render the constancy of the supply absolutely reliable, for the machinery might break down owing to accident or wear, and the district be deprived of light until the necessary repairs were made. Therefore it is essential that a reserve of electricity, independent of the generating plant, should be at hand, and such a reserve can only be obtained by the use of storage batteries.

The subject of electric lighting in conjunction with storage batteries is one that is receiving considerable attention from a good many engineers at the present time. The desirability of working with them has, I think, been admitted by most engineers for a long period, but the difficulty in connection with their use has been great. Among other things, the durability and efficiency of the battery itself has been more or less an unknown quantity, and this has caused people to hesitate before embarking upon any large amount of work dependent on them. It is hardly my province now to go into the history of the several methods which have been tried, but we may simply look on the two broad modes of working, viz., charging batteries in multiple, or charging them in series. As we do not in this system propose to charge in multiple we can leave that out of the question. We may therefore consider the mode that we are here adopting of charging batteries in series. It has been found to be most economical to use comparatively small conductors with suitable current and high electromotive force enabling one to carry the current over long distances from central stations, and to supply the current at different points on the line, as may be required for local work or use.

An opportunity for distributing current over a large area was presented to me some months ago, where a central station was available, suitable as to its position and size, but a long way from where it was intended to supply the bulk of the current for lighting purposes. It was necessary to consider the respective advantages of direct supply with low tension and high tension in conjunction with transformers. The former was out of the question on account of the distance, and the latter was at that time in disfavour, owing to several breakdowns and interruptions of the light to consumers having been reported in London. It was therefore deemed desirable to work in conjunction with a reserve, such as storage batteries in some form or other, and the idea occurred to me that a system might be developed which would practically be analogous to the transformer system, but using direct in lieu of alternating currents, and charging batteries in series with a constant current on one main line, rather than in parallel, and simply increasing the E.M.F. as the work increased and as the length of the line extended. This might be done in several ways, by dividing the line into sections, charging each portion for a good number of hours according to the probable demand, or by an arrangement for supplying current from the main to a portion of any group of cells less than the whole; but here a difficulty occurs, for it is most undesirable to be charging batteries as a whole or in part at the same time that they might be wanted for discharging. To obviate this, the batteries might be duplicated, so that one portion might be in the charging main and the other in the local. But this, again, is limited by the number charged in series at the same time. Besides this, the cells that have been charged have a large difference of potential when brought into the local, which causes a fluctuation of lights when such changes occur.

This brings us to the system which I have devised. Sets of accumulators are placed in groups at various points or sub-stations throughout the district to be lighted, and charged in sections from the central station. The secondary batteries at each sub-station are divided into four equal groups, with any convenient number in each group. For instance, we may have four sets of eight cells each, of which three sets, or 24 cells, will always be in connection with the lamp circuit, and supplying current locally to those houses which are in connection with the sub-station; while the fourth section will be in the main circuit, in series with the other sub-stations, being charged by the current from the central station. At short intervals the charged group is switched out of the main circuit into the supply, its place being taken by one of the discharged groups. In order that the three groups in the supply circuit shall be as far as possible in an equal state of charge, it is essential that the changes should take place at frequent intervals, otherwise one group would become highly charged while the other three are being nearly exhausted. Therefore, I have designed an apparatus by which each group is brought in succession into the charging circuit, charged for a short period—two minutes in actual practice—and then removed again into the supply circuit, in order that it may discharge itself. This apparatus I call a distributor.

The operation of the distributor may be understood from the diagram on the following page. You will see that the four groups of cells are lettered A B C and D. H H is the main charging conductor, H 2 H 2 the branch conductor, and L the local installations. Y a resistance.

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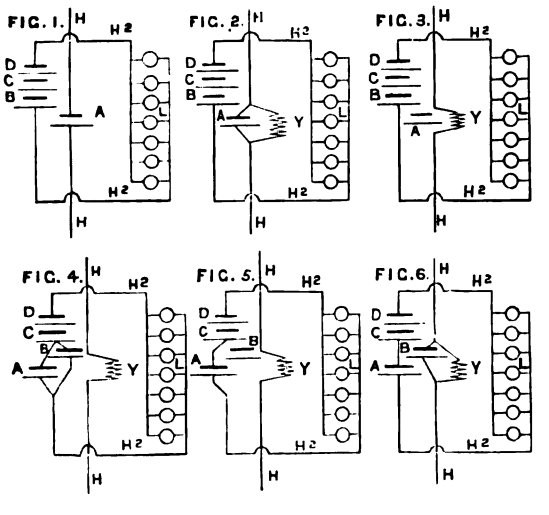
In Fig. 1 the battery A is shown in the main conductor being charged, while batteries B, C, and D are connected together in series, discharging locally. In Fig. 2 the resistance Y is connected in parallel with the battery A, thus giving a by-path for the main current, which now divides itself between the two circuits, viz., the resistance and the battery. In Fig. 3 the battery A is now disconnected from the charging main, the resistance Y carrying the whole of the current, and maintaining the continuity of the charging circuit. You will observe that battery A is now free, and is to be removed to the local circuit. In Fig. 4 this is effected by coupling it in parallel with battery B. You will observe here that the two negative poles of the batteries A and B are coupled together to the local negative, while their positives are coupled together to the negative of local C. We have thus been enabled to introduce A into the local circuit without causing any alteration in the E.M.F. of the series or censequent fluctuations in the local circuit.

We can now, as in Fig. 5, isolate the battery B from the local battery, A having taken place, maintaining the continuity of the local. Battery B is now connected with the main in parallel with resistance Y, as in Fig. 6. Resistance Y is then cut out, leaving battery B to receive the full charging current of the main H H, it practically being the substitute for battery A, as in Fig. 1.

These cycles of changes are essential to the efficient carrying out of this system, for we must guard against interrupting the main charging circuit, because of other work going on in the circuit at the same time in series with the battery under consideration. We must also be careful at no time to alter or fluctuate the pressure of the local batteries. We must also at no time have the charging main in contact with the local batteries, as this might cause a variation in their pressure, or in an extended system have a tendency to leaking through the local to earth, with its attendant dangers. You will see, therefore, that by carrying out this cycle we ensure all the requisite conditions.



In practice this cycle of changes takes piace at intervals of about every two minutes, the batteries A B C and D receiving their increments of charge, A for two minutes, B for two minutes, C the same, and D the same; so that in eight minutes each of the cells will have received two minutes' charge. The charge now proceeds in the reverse direction from D to A; thus the cycle is A B C D D C B A, &c.

Although the process of describing in detail the changes which are shown in the diagrams, and which complete one cycle, have been somewhat lengthy, it must not be supposed that the actual change in the mechanical-electrical actions of the distributor which bring about this result are of any protracted period of time. If so, the value of the system would be neutralised. The actual time occupied is less than one second, so that in 24 hours the distributor instrument is only actually under movement for 12 minutes. This practically consumes very little time, and prevents any appreciable wear of the moving parts.

But it will be observed that in 24 hours we only charge a group of cells, as a whole, with a six hours' current. On the other hand, we only want one-third of the charging potential in the main. This enables us to do a given amount of work with one-third of the plant, and one-third of the pressure at the charging station, compared with what would be required if we were doing the same amount of work by a direct system. This is very important. The cells are kept in much better condition by continually receiving fresh increments of charge, and having periods of rest from discharge. Also, the loss due to difference of potential between the charging and discharging current is minimised, it being found in practice that we can continue charging the cell to its maximum capacity with a mean voltage of 2·25, instead of 2·5 per cell, as is required where cells are charged continuously. This, on a large scale, is a considerable element of economy when there are a large number of cells in the charging main. Besides this, we find that an approximately constant potential on the local circuit enables us to run lamps at a higher efficiency without the risk of rupture due to sudden rise of pressure, and, so far as we can judge, the current supplied from the dynamos at the central station is 70 amperes, this being the amount by which the large-sized E.P.S. cells are best charged. The voltage of the dynamo varies according to the work at any one time on the line, and the current is maintained constant at all times. A simple mode of ensuring these results has been obtained by using an ordinary series dynamo, whose field is excited from a separate source, by batteries, for example, incidentally charged from the main, and the speed of the dynamo is varied in accordance with the variations of the work or external resistance of the circuit. I find that by proportioning the size of the engine to the dynamo it has to operate we need only keep a constant pressure on our engine to ensure the regulation being entirely automatic. We have been able to dispense with electric regulators of all kinds in the station, for the dynamo practically regulates the speed of the engine, only going at a given speed in order to produce the requisite E.M.F. to supply the 70-ampere current through the whole of the work in circuit at any time. Should batteries be cut out of circuit the result is that the resistance is lessened, upon which the volume of current is increased. This immediately acts like a brake on the engine, causing it to run at a less speed until it has accommodated its speed to the normal 70 amperes, provided that meanwhile the steam pressure in the cylinder has been kept constant. This can conveniently be done by means of an ordinary steam pressure regulator. Should, however, more work be included in the circuit, the result will be that the current will suddenly fall, freeing the breaking effect on the engine, causing it to respond and run at a higher speed, until such time as it has brought up the current to the normal of 70, of course demanding more steam, which the stoker must look out for. In this way it is only necessary, by means of a speed counter, to take the revolutions of the engine or dynamo of the station at any time as being an exact index of the work going on at that time, and, as the work increases when the speed of any one engine gets up to its mechanical limit of safety, two or more machines are then brought in series with the others, and, acting in the manner already described, keep this constant current with its proper potential always on the main circuit. Having a time apparatus to effect the changes described in the battery, and a constant current in the main, it is only necessary to bring these two together, as the tension on the batteries is practically the same, in order to form a very efficient and simple meter, which, having only to deal with the current supplied in the charging, has not to differentiate and take account of the varying amounts used in the discharge.

Of course, it may be said that a system of this kind is essentially dependent on the mechanical details used for carrying the same into effect, and here actual practice has been of very great use to me. The Cadogan Electric Light Company, of Chelsea, having adopted this system, has enabled me to see actually what such shortcomings were. The apparatus I have here to-night is of the kind that has been in use there, and like all first forms, has not performed as well in practice as it did with the care and attention it received in the laboratory.

The apparatus here consists of a powerful electro-magnet driving a set of cams, which operate four levers, each lever carrying a full set of combination of contacts for each of the groups of batteries in use at one time. This reciprocating lever arrangement, however, has shown a serious difficulty, for the levers have occasionally wedged themselves so tightly that the electro-magnet could not draw them out, or, on the other hand, have proved too slack, so that insufficient contact was made, and sparking and heating caused in the apparatus. All this, I am glad to say, has been got over by the substitution of a rotary for a reciprocal motion, and now I can show you an improved form of apparatus, which is doing the work here this evening, which carries out all the requirements of this system in a much simpler manner. When any group of cells are sufficiently charged so that they ought to be disconnected from the charging main, an arrangement called a voltage regulator is brought into use. This causes the batteries to be disconnected from the main, and to remain disconnected until such time as they are discharged sufficiently to reduce their E.M.F. to a lower level, when the apparatus automatically causes the battery to be again put into the charging main. It will be obvious that such a system as this is is sufficiently elastic by varying the number of cells to give practically any potential that may be demanded, and can therefore comply with all kinds of requirements for lighting, arc or incandescent, or supplying current for other purposes. It is very desirable not to have too great a variety of pressures, and therefore in houses where but a small amount is demanded it is best to put down a plant of sufficient size to supply several together from one distributor, thus forming a

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small station, it being, however, always desirable to have the same as near as possible to the point of consumption, and much cheaper to carry our charging main there than to have the local discharge mains. It is convenient not to have such stations too large, or at too great a distance from their work. For suburban or scattered lighting this system is very useful, as only one main is required of, say, three-eighths of an inch cross-section, which can be conveniently carried overhead or underground.

In this Paper I have not gone into the question of cost, but from the experience we have had think that such a system compares most favourably in this respect with any of the direct or alternating-current methods, and I hope it will prove a means of supplying that great demand which all engineers feel is now upon us.

OUR SUPPLEMENTS.

THE SOUTH AFRICAN CABLES AND THE ELECTRIC LIGHT AT SOUAKIM.

We publish as supplements this week a map showing the projected extension of telegraphic communication to the Cape of Good Hope, and a plan of Suakim, illustrating the value of the electric light in warfare.

It is now about nine years since South Africa was connected telegraphically by means of a line of cables on the East Coast of Africa from Aden to Durban, with stations at Zanzibar, Mozambique, and Delagoa Bay. More recently cables were laid on the West Coast, starting from St. Vincent, by the African Direct and West African Telegraph Companies, which carried the communication as far south as Loando. At a meeting of the shareholders of the Eastern and South African Company, held yesterday, authority was given to raise the necessary capital to lay a cable which should have been represented on the map by a *dotted* line, from Cape Town to Mossamedes, Benguela, and St. Paul de Loando, where it will join the existing cables, thus placing the Cape of Good Hope in direct submarine telegraphic communication with this country, and affording an alternative route to that on the East Coast.

The fact that in the space of ten years Africa should be almost completely encircled by the telegraph affords a striking example of the rapidity with which submarine communication is being extended. It may be said that the eyes of all Europe are turned to the Dark Continent, and that all the nations are interested in its development. In view of the immense possibilities of its future it is interesting to note the commercial enterprise which has connected telegraphically all the important points on its coast with the rest of the world at a time when only an infinitesimal portion of its immense territory has been brought under the influence of civilisation.

The state of affairs at Suakim is an instance of the "surf which marks the edge of the advancing wave of civilisation," as Lord Salisbury said the other day.

A correspondent on the spot says: "There is not the slightest doubt that leaving Suakim without the protection of men-of-war, after H.M.S. 'Dolphin' and 'Albacore' cleared out on the 17th July, owing to heat and sickness, and allowing the electric light to fall into disuse, are the causes of the dilemma we are now in. Earthworks sprang up over night as if by magic, which could not have happened had the electric light been kept in order.

"After a cricket match the other evening the sentry telephoned in 'Tent gradually moving westward,' and before things could be made clear the tent (which had been left on the cricket ground), and under which the rebels had got and cut the ropes whilst keeping it open by their numbers, was carried bodily away under the very noses of the fort gunners, who could not believe their eyes."

It will be remembered by readers of the daily papers that the light on Quarantine Island was repaired by the staff of the Eastern Telegraph Company's ss. "John Pender," and that on Shaata Gate- which is the more important, being 1,500 yards nearer the trenches—by the officers of the same company's ss. "Electra.'

The plan which we give is from a sketch by the electrician of the latter vessel.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 10th*, 1888.

The American Gas Light Association has recently held its 16th annual meeting at Toronto, Canada, where it was warmly received by the gas interests of the Dominion. In his opening address, the president, Mr. T. Turner, of Charleston, South Carolina, made an interesting reference to the relations between gas and electric lighting. In congratulating the members on the general and almost unprecedented prosperity of the business during the past year, he took occasion to ask the question whether any explanation of this large increase in the quantity of gas called for could be given, particularly in view of the fact that the electric light is now a far from inconsiderable portion of the light used in large cities. He answered his own interrogation with several reasons. The first of these was the natural tendency of all the consumers towards the use of more light; the second was the low price at which gas was now offered and sold; a third, and main reason, was that the application and use of the electric light had the effect of compelling people to use more light. He thought they ought to be generous and give the electric light credit for its assistance in increasing the sales of gas. Some gas companies and gas engineers, he remarked, had pursued the policy of fighting the electric light. "This," said Mr. Turner, "I regard as a mistaken policy. No gas company or gas manager can afford to stand in the way of the development and march of improvements of any kind. Development and improvement are the order of the day in this age. The world must go forward, onward and upward toward perfection, and the man or men who would endeavour to stop the wheel of progress does not comprehend the tendency or drift of things in the age in which we live. The electric light has its advantages; let us acknowledge them. It also has its defects, which are ample enough to interfere with its progress to that extent." In view of the persistent experiment and research for the last 10 years in the development of the science of electricity, as applied to the production of artificial light, the only inference that could be formed was that illuminating gas had certain qualities which insured its continued use for an indefinite time. Mr. Turner admitted that the market price of gas stocks had at times been lowered by the progress that the electric light had made and is making; but he held that the business, as a whole, had not suffered. Although such were his opinions on the subject, Mr. Turner was not entirely in favour of the policy of amalgamating the business of gas lighting with that of electric lighting. He could not see why gas companies should engage in electric lighting any more than they should attempt to handle kerosene oil and candles. He doubted the ability of a man to manage two such different and dissimilar businesses, and thought that the combination plan must result in the neglect of the one interest or the other. In some instances advantages might accrue from consolidation; but still he thought that the attempt at monopoly was of dubious wisdom. Mr. Turner has evidently given serious and mature thought to the subject; but we may judge, from what goes on around us, that gas managers generally do not agree with him. A great many gas companies are in the business of supplying the electric light, and their number is daily added to, while, in a great many other instances, the combination of the two interests under one management, or under the control of the same capital, has been effected.

American electricians have been very much interested in the accounts which have reached here of the revival of electric lighting in England, and of the movement now on foot to undertake the supply of current on a larger scale. The news from London, both in regard to the purchase of Westinghouse apparatus and the starting of work on the two-million light station at Deptford, has caused a great deal of discussion. When the latter project is actually carried out it will be time, perhaps, to discuss it on its merits; but the general idea here seems to be that it is hardly worth while to tie up so much generating capacity in one unit, greater safety and better results being attained with a little more subdivision. I do not think

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that there is any likelihood of any station of that size being built yet awhile in this country. In this city, for example, if any such plan as the supply of two million lights were entertained, it would probably be decided to divide the city into districts, and to establish a station for each. This is virtually what the Edison Company has done with its system of direct current, and I do not think there would be much departure from that practice even with the alternating current. Our arc lighting companies, for example, have found it best, from practical experience, to divide up their capacity into three or four stations, each of which looks after its own section of the city, and can, in case of emergency, throw its current into the circuits of the other stations, should those stations happen to be cut off or disabled in any way.

Montreal, Canada, is promised a telephone rate war. A new corporation, called the Federal Telephone Company, has been preparing for business for some time past, getting up its poles and wires in spite of a good deal of opposition. It is now supposed that they will be ready some time in the spring, but in the meanwhile the old Bell Telephone Company of Canada has given notice that it will cut its subscribers' rates in Montreal at the beginning of the new year to $25 per annum. The former rate of the company was $50. A *pro rata* rebate to the present subscribers is to be made by the extension of their leases. This is intended to destroy the effect of the tempting offer made by the new competing Federal Company, which proposes to do business at a rate of $35 per annum. It is thought in some quarters that the new company will find it rather uphill work under such a state of affairs, but we may at least look for a very lively competition.

The Thomson-Houston Electric Company have just begun work on an electric railway at Topeka, Kansas. The road will be 14 miles in length, will have about 30 or 40 cars, and will cost somewhere in the neighbourhood of from £40,000 to £45,000. This plant, it is said, will be the largest in the world, exceeding even that at Richmond. The overhead system will be used. The generators will be run by two Corliss engines of a total of 700 horse-power, with boilers of 800 horse-power. A special new station is to be built for the work, 85ft. by 100ft., two stories high, brick and stone. Each car will carry two motors. Work is to be pushed ahead at once in this installation, and it is expected that the road will be running by January 1. It will be seen from this that we are well into the era of large electric roads. Only a few short months ago a great many people were disputing the ability of the electrical engineers to operate more than one or two cars on a road, but now we have such large roads as those at Richmond, Scranton, Dayton, Akron, and Appleton, and larger new ones like those at Topeka, Boston, Cleveland, and Omaha.

I believe I have alluded before in this letter to the ravages of the yellow fever at Jacksonsville, Fa., and to the gallant stand made there by the staff of the telegraph and telephone companies. A great deal of quiet courage has been shown, and the officers and operators have stood manfully to their posts amid all the terrors of the plague, and under the burden of tremendous overwork. The New York *Electrical Engineer* of this month mentions one instance of a young girl, Miss Mamie Davis, who held her post in the telephone exchange when left entirely alone for a time during the epidemic. At one period everybody was down with the fever excepting herself; but there she sat at the board from morning till night, snatching hurried mouthfuls of food between the calls for doctors, undertakers and ambulances, and never flinching or thinking she was doing anything heroic or out of the way. I trust and believe that the little heroine will be remembered by the company in some substantial manner, and I take this opportunity of placing the homage of one admirer at her feet.

Another instance of the gallant spirit of our Southern folk is seen in the fact that the Jacksonville Electric Light Company, in spite of all the depression of business from the epidemic, has gone ahead with plans for enlarging its plant. Perhaps they have been stimulated to this by the new theory, just advanced, that the microbes flourish in darkness, and that one of the best means for their extirpation would be an overwhelming flood of light such as is given out by the electric arc.

The telephone companies have been very busy this week handling the returns of the Presidential and State Elections. I do not think, however, that the total of the matter sent and received will equal that of 1884. At that time the general result of the vote was in doubt for some days, and there was consequently an unstinted use of the wires by the newspapers. This year the result was practically decided on the same night, and the only point which has interested the people since has been the size of the majorities; so that the necessity for the use of the telegraph on a large scale has not been very marked, except in the supply of special returns on election night. A new feature of the work was the receipt on Tuesday night, from various parts of New York State, of long-distance telephone despatches; and the announcements were so labelled on the bulletin board. I have not seen this use of the service made so prominent before, and I have no doubt that it acted as a good advertisement of the new convenience to the thousands of people who assembled in breathless excitement all night long in front of the newspaper offices, at the political headquarters, and underneath the sheets of the stereopticon.

I suppose you are aware by this time that the election has gone against Mr. Cleveland, and has therefore given a setback to the movement for tariff reform. As a general thing this is regarded with favour in electrical circles, although opinion is by no means unanimous on the subject. One of the incidents of the election has been the defeat of Mr. Hewitt, as mayor of this city for a second term. Mr. Hewitt, as you may remember, has been the ally of the local arc light companies in their opposition to the plans of the Subway Board. He announced that until he saw a thoroughly practicable and feasible underground system he could not be a party to compelling the companies to take their wires off the poles; and he has been as good as his word. The result has been a state of affairs not unlike a deadlock, the Subway Board being checked in its efforts by the opposition of the mayor, and the apathy of the officials working under his jurisdiction. Now, however, the scene changes. The new mayor in the pre-election declarations that outlined his policy pledged himself to active work in the removal of the wires. This incoming mayor, Mr. Grant, is the nominee of Tammany Hall, our big Democratic club, which has been successful in returning its candidates throughout the city for every office for which they were nominated; and now that they are deprived of the support of the mayor the electric light companies are going to have a rather hard time of it in being subject to the tender mercies of Tammany Hall and its cohorts. Mr. Grant, personally, is regarded as a clean man, in the political sense, but he is not stronger than his party. It may not be unworthy of mention that Mr. Ed. Stokes, who has had an interest in the affairs of the Postal Telegraph Company, the only rival of the Western Union, is popularly regarded as one of the powers behind the throne in Tammany Hall.

CORRESPONDENCE.

THE ELECTRO-MAGNETIC EFFECT OF A MOVING CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question raised by S. P. Thompson (p. 54, Nov. 16) as to whether the motion of an uncharged dielectric through a field of electric force produces magnetic effects must, I think, be undoubtedly answered in the affirmative. As the distribution of displacement varies, its time-variation is the electric current, with determinable magnetic force to match. When the speed of motion is a small fraction of that of light we may regard the displacement as having at every moment its proper steady distribution, so that there is no difficulty in estimating the magnetic effects, except, it may be, of a merely mathematical character. For instance, the case of a sphere moving in a field which would be uniform were the sphere absent, is readily attacked, and does perfectly well to illustrate the general nature of the action.

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But if the moved dielectric have the same electric permittivity as the surrounding medium, so that there is no difference made in the steady distribution, the question which may be now raised as to the possible production of transient disturbances is one to which the above theory does not present any immediate answer. I believe that the body will be magnetised transversely to the electric displacement and the velocity.

Another question, somewhat connected, is contained in Poynting's suggestion (in letter to Lodge, p. 829, Vol. XXI.) that electric displacement may possibly be produced without magnetic force by the agency of pyroelectricity. But, whatever the agency, it would, I conceive, be a new fact—quite outside Maxwell's theory legitimately developed. We may have subsidence of electric displacement without magnetic force; but I cannot see any way to produce it.

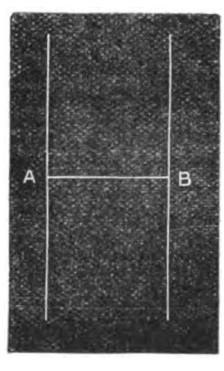
But the main subject of this communication is the electromagnetic effect of a moving charge. That a moving charge is equivalent to an electric current element is undoubted, and to call it a convection current [surely not "convexion"], as S. P. Thompson does, seems reasonable. The true current has three components, thus,

$$\text{curl } \mathbf{H} = 4\pi(\mathbf{C} + \dot{\mathbf{D}} + \rho\mathbf{u}),$$

where $\mathbf{H}$ is the magnetic force, $\mathbf{C}$ the conduction current, $\mathbf{D}$ the displacement, and ρ the volume-density of electrification moving with velocity $\mathbf{u}$. The addition of the term $\rho\mathbf{u}$ is, I presume, the extension made by Fitzgerald to which S. P. Thompson refers. At any rate I can at present see no other.

There are several ways of arriving at the conclusion that a moving charge must be regarded as an electric current; but, when that is admitted, we are very far from knowing what its magnetic effect is. No cut-and-dried statement of it can be made, because it varies according to circumstances. The magnetic field, whatever it be in a given case, is not that of a current element (supposing the charge to be at a point), for that is anti-Maxwellian, but is that of the actual system of electric current, which is variable.

Thus, in the case of motion at a speed which is a small fraction of that of light, the magnetic field (as found by J. J. Thomson) is the same as that of Ampère's current-element represented by $\rho\mathbf{u}$; that is, a current-element whose direction is that of $\mathbf{u}$ and whose moment is ρu, if u is the tensor of $\mathbf{u}$ (understanding by "moment," current density × volume); but the true current to correspond bears the same relation to the current-element as the induction of an elementary magnet bears to its magnetic moment. The magnetic energy due to the motion of a charge q upon a sphere of radius a in a medium of inductivity μ, at a speed u, which is only a very small fraction of that of light, is expressed by $\frac{1}{3}\mu q^2 u^2/a$. But if the speed be not a small fraction of that of light, the result is very different. Increasing the speed of the charge causes not merely greater magnetic force but changes its distribution altogether, and with it that of the electric field. It is no use discussing the potential. There is not one. The magnetic field tends to concentrate itself towards the equatorial plane, or plane through the charge perpendicular to the line of motion. When the speed equals that of light itself this process is complete, and the result is simply a plane wave (electro-magnetic).



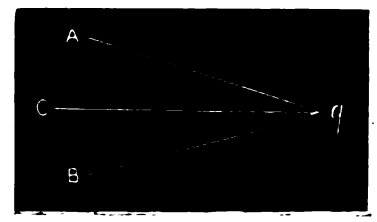
Since a charge at a point gives infinite values, it is more convenient to distribute it. Let it be, first, of linear density q along a straight line AB, moving in its own line at the speed of light. Then the field is contained between the parallel planes through A and B perpendicular to AB, and is completely given by

$$E/\mu v = H = 2qu/r,$$

where E and H are the intensities of the electric and magnetic forces at distance r from AB. The lines of $\mathbf{E}$ radiate uniformly from AB in all directions parallel to the planes; those of $\mathbf{H}$ are everywhere perpendicular to those of $\mathbf{E}$, or are circles centred upon AB. Outside this electro-magnetic wave there is no disturbance. I should remark that the above is a description of the *exact* solution. It is, of course, nothing like the supposed field of a current element AB.

To still further realise, we may substitute a cylindrical distribution for the linear and then, again, terminate the lines of $\mathbf{E}$ on another cylindrical surface between the bounding planes. To find the resulting distributions of $\mathbf{E}$ and $\mathbf{H}$ (always perpendicular) may be done by super-imposition of the elementary solutions, or by solving a bi-dimensional problem in a well-known manner.

Those who are acquainted with my Papers in this journal will recognise that what we have arrived at is simply the elementary plane wave travelling along a non-distortional circuit. All roads lead to Rome!



Returning to the case of a charge q at a point moving through a dielectric, if the speed of motion exceed that of light, the disturbances are wholly left behind the charge, and are confined within a cone, AqB. This charge is at the apex, moving from left to right along Cq. The semi-angle, θ, of the cone, or the angle AqC, is given by

$$\sin\theta = v/u,$$

where v is the speed of light, and u that of the charge. The magnetic lines are circles round the axis, or line of motion. The displacement is away from q, of course, and of total amount q, but not uniformly distributed within the cone. The electric current is towards q in the inner part of the cone, and away from q in the outer.

It will be seen that the electric stress tends to pull the charge back. Therefore, applied force on q in direction Cq is required to keep up the motion. Its activity is accounted for by the continuous addition at a uniform rate which is being made to the electric and magnetic energies at q. For the motion at the wave front, at any point on Aq or Bq, is perpendicularly outward, not towards q. Whilst the cone is thus expanding all over, the forward motion of q continually renews the apex, and keeps the shape unchanged.

Steady motion alone is assumed.

To avoid misconception I should remark that this is not in any way an account of what would happen if a charge were impelled to move through the ether at a speed several times that of light, about which I know nothing; but an account of what would happen if Maxwell's theory of the dielectric kept true under the circumstances, and if I have not misinterpreted it.—Yours, &c.,

OLIVER HEAVISIDE.

November 18, 1888.

THE SPRAGUE MOTORS AT RICHMOND AND MR. ALBION SNELL'S CRITICISM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of August 31st contained a Paper entitled, "The Sprague Motors at Richmond, Va.," by Albion T. Snell, which, while deprecating any intent of captious criticism, contains at once, with some interesting comments, several most un-

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justifiable conclusions, which a fuller knowledge of the subject would have led him to avoid. I do not think the question whether the English electrical engineers have anything to fear from their brethren on this side of the Atlantic is an important one in this connection. Whatever the self-complacent conclusions to which Mr. Snell may have arrived, it is quite within the possibilities that all competent electrical engineers can design motors of equal electrical and mechanical efficiency where no limitations are put upon them; but what is a matter of more importance is how far the purely electrical deductions of the school or laboratory shall be subordinated to mechanical and commercial considerations, and if we are to judge by the relative advances made in England and the United States, I think the credit can be claimed for the Americans of dealing with these questions in a more matter-of-fact and pertinent manner. This may be acknowledged after due weight is given to the difference between English and American public spirit and enterprise, which same difference may possibly exist between electrical engineers of the two nationalities.

Novelty alone does not win in the United States, nor would a knowledge of the business done confirm the opinion that liberality of public spirit is the chief reason of success. One thing seems to be forgotten by an Englishman when discussing things American, and that is the fact that a newly-developing business of special character is carried on with New York as a centre in places which may be as far away as Boston or Halifax, Smyrna or Trieste, or Constantinople is from London, and that it may take seven days of continuous travel to reach a point where work is being progressed. Does a liberal public spirit, may I ask, guarantee the success of an enterprise under such conditions? If so, the public spirit of our people in this widely-diversified country is, indeed, liberal.

Turning to Mr. Snell's Paper, I find that he asks concerning certain curves published in a Paper read before the American Institute of Electrical Engineers, "Why were they ever published in their present form?" especially in view of the omission of allowances for material friction, self-induction, &c. These omissions being so apparent, it would seem that Mr. Snell's statement concerning them, that they are theoretical curves, might have been accepted as a fair explanation and so treated. The curves are not, however, entirely theoretical. They are based partly upon experiments, partly on theory, and are useful for pointing out in a general way the approximate shape of certain characteristic curves of a motor under one condition of working, and some new uses to which such curves, assuming them to be correct, may be put. They have the same value that a theoretical steam diagram may have, and serve a purpose which is just as well attained for the layman as perfectly accurate ones, and, in fact, they must first be understood before the more accurate and elaborate curves can be fairly considered. If a strictly correct representation of a machine is to be made, much more numerous curves must be laid down than those suggested by Mr. Snell, and should be given in comparison with the theoretical ones. Many of his remarks are, however, interesting and to the point, and a more useful analysis of the motor would have been given had his method been adopted in conjunction with my own, and hence I may be permitted to make some comments on his criticism.

Referring to the diagram published in your issue of Aug. 31, the curve O A gives the average electromotive force of a particular armature when running at a determined speed with an increasing and decreasing field and for constant and periodic work, and takes into account self-induction (which lowers the curve) and the distortions set up by the armature current which would exist with the field coils in a particular relation; it can be obtained no matter how the field coils are excited so long as the ampere turns correspond and are proportional to the armature current. This curve is, of course, a variable one when a large number of machines are built and when the conditions of actual work are considered. Its flattening is due rather to scantiness of wrought iron, and the use of cast iron, in the magnetic circuit, and the length of the latter, as well as to the distortion set up by the armature—faults which commercial demands are largely responsible for.

The line of motor electric motive force in terms of the resistance and current should, of course, be slightly concave, because of the self-induction of the coils leaving the brushes, or it could be made straight by varying the graphic unit of current.

We would have in practice $C = \frac{E - (e + e')}{R}$, where e' is the induction increment, its value depending upon the turns of the wire and the current.

The speed curve in terms of the current E D C does not in practice for these particular machines depart very seriously from that given within the actual limits of working, the speeds being, in one of the stock machines recently tested, and probably with fair accuracy, as follows:—

Amperes.	10	15	20	25	30
Sprague curve ...	1,167	900	775	690	630
Actual	1,185	946	806	687	603
Snell's curve* ...	967	860	667	600	540

being thus greater than my curve readings when less than 25 amperes, and less than these when greater than 25.

As regards the work curve, it is an ordinary practice in rough work to plot it for horse-power $= \frac{Ce}{800}$ instead of $\frac{Ce}{746}$, and then to allow for any interesting work curve an increase of 10 per cent. for material friction.

Absolute accuracy is not quite practicable except in a laboratory. The expression horse-power $= \frac{Ce}{746}$ is a true one, but it does not of course represent the brake horse-power, since it includes useful work: air, commutator, journal, and gearing friction; air fanning; work expended in generating eddying currents in the armature discs and binding bands, and in the pole pieces; the work of overcoming self-induction in the coils leaving the brushes; and energy expended in short-circuited coils. The aggregate of the prejudicial classes of work would nearly bring the curve O F C to Snell's curve 4; but the ultimate reading of the characteristics of an intersection would be about the same as would be afforded by plotting the work curve as horse-power $= \frac{Ce}{800}$, and allowing an increase of 10 per cent. in the equation for car work, as was done; the former method is, of course, a truer indication.

The curve O D G, giving the work of the motor in terms of its own speed, would, if plotted from E D C, corrected for self-induction, and O F C, corrected for material losses, be perfectly accurate, because it is simply based upon the facts indicated by these curves, and is plotted from transferred co-ordinates. Similar remarks are true concerning the curves of torsional effort.

Mr. Snell makes a most serious mistake when he assumes that these machines are designed to be run with the greatest normal output with half the maximum current—in other words, at about 14·5 horse-power, and with over 50 amperes of current; and he points out the great heat loss which would exist under such circumstances.

He asks, "How long would a motor run with a furnace inside it?" and immediately afterwards says, "and note the car speed for this current is about three miles per hour, and so this must occur frequently;" he then naively adds, "well, the writer cannot explain this, &c." With the consciousness of this lack of explanation, because of the knowledge that the assumption is entirely untenable, Mr. Snell should, it seems, have hesitated before jumping to hasty conclusions. True, it is said that the motors can for a short time work up to double their normal capacity, and considering the fact the line potential can be readily raised to 500 volts, and that for a few seconds, under some very abnormal conditions, such as one motor being broken down on a very heavy grade, or with a car off the track, a motor may be put under a most exceptional strain, the remark is fairly true; but the assumption of Mr. Snell is that because the car must be often running at three miles per hour this over-load must be a normal condition of affairs. While I did not explain any particular method of governing these machines, I did say that they were commutated; and the key to the explanation lies in the difference between English and my practice in street car motor government.

* It is perhaps desirable that we should remark that Mr. Snell's curve is itself an "actual" curve.—Ed. *E.*

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One of the things which are concerned is the total efficiency of the car circuit, which circuit includes the motors and the governing devices; but this is not all. The speed at which, with a total determined car circuit efficiency, series motors will run is of equal importance. There are three general methods of controlling motors: one (and it seems Mr. Snell's favourite) is to make use of external resistance, leaving the motor circuit undisturbed; another is to make use of both the external resistance and certain changes in the motor circuits; a third is to govern the motors entirely by variations in the arrangement of the field coils.

I have used all methods, but the last is characteristic of the Richmond machines. Their fields are wound with three sets of coils, varying in the number of turns, the cross-section of the wire, and the resistance; these are connected with a switch, so that when the motor is thrown into circuit the field coils are all in series and have a definite high resistance. The coils are then progressively commutated till they are finally thrown into multiple circuit, and have a resistance of only one-ninth that first existing. In this way a fairly constant field may be maintained for currents varying 300 per cent., and the motor be made to meet any required conditions; while for any particular arrangement of the coils many of the advantages and characteristics of the simple series motor are retained. The great advantage of this method is that with any light load and with a given total efficiency of the car circuit the motor will run at a much lower and constant speed than if made with a fixed series field resistance and governed by a resistance coil; part of this governing can be accomplished by changing the armature circuits, but this method has such disadvantages that it was after a long trial in Richmond finally discarded.

As regard the Richmond motors, they are by no means perfect machines, and they have been called upon to do an abnormal amount of work, much more than was ever anticipated; the normal maximum load should be about 7½ horse-power including friction, and they will develop this with about 18 amperes of current on a 400-volt circuit. The ratio of the motor electromotive force to the electromotive force existing at the terminals of the armature is then about 93 per cent. The average current through the machines is not over five to eight amperes. When we consider that the machines have to be built to work up to 500 volts, if necessary, with the base frame in circuit and hence necessarily well insulated, and in addition must be able to stand instant reversal with a heavy load on a 10 per cent. down grade, and were, furthermore, built to meet certain demands in regard to space, cost, &c., I have yet to hear of an English machine to meet like conditions more successfully.

Mr. Snell says that English practice would be to make a machine of equal capacity of about ·65 ohm resistance; but it may be a pertinent inquiry to ask *what* English machine, built for like conditions and service, to meet the same commercial demands and governed in the same way, and with a normal maximum brake load of 7½ horse-power on a 400-volt circuit, is built to have a total resistance of motor and regulating apparatus of ·65 ohm? There is none. On the other hand, on the same page Mr. Snell says: "In ordinary English practice a motor absorbing 50 amperes and, say, 100 volts, and running an eight-ton car at about three miles per hour, would have an internal resistance of ·25 ohm, &c." There seems to be some confusion in the unquoted part of this statement; but if the motor has ·25 ohm resistance on a 100-volt circuit, it will measure, because of the increased space taken up by insulation, somewhere about 4·5 ohms on a 400-volt circuit—a considerably higher resistance than that of the Richmond machine. No grade being given for these figures of Mr. Snell, they are supposed to be for working on an English tramway at level. One of the Richmond machines will easily run such a car under the same circumstances about six miles per hour.

As a matter of comparison between English and American machines, possibly the following figures will give Mr. Snell food for reflection.

One of our latest railroad machines, designed to work on a circuit varying from 400 to 500 volts, and up to a normal capacity of the former potential of 12½ horse-power, has a resistance of about 1·4 ohm on the last step. The normal magnetic circuit outside of the gap is entirely of wrought iron, and the characteristic of the machine up to its normal load is very nearly a straight line, and about equal to that of the best Edison-Hopkinson dynamo.

One of our earlier machines was a motor designed to develop 15 horse-power on a 220-volt circuit. A special committee from the Massachusetts Institute of Technology about a year ago tested one of these machines at 186 volts, a brake-load of 21 horse-power, and with about 60 per cent. current over load. Its commercial efficiency under these abnormal conditions was 78 per cent. Some of our standard machines have the following characteristics:—

Capacity. Horse-power.	Volts.	Armature Resistance.	Shunt Field Resistance.	Ratio of Resistances.
20	220	·082	150	1,829
25	220	·058	140	2,414
30	440	·228	440	1,930

The ratio of motor electromotive force to the initial when under full load is, say, for the 25 horse-power motor nearly 98 per cent., and all these machines have a commercial efficiency of over 90 per cent.

I should be glad to know of any English machines, whether of 1885 or 1888 design, which leave much to be desired in the above in the matter of regulation or efficiency. I have given these figures to show the uselessness of Mr. Snell's self-complacent disparagement of American machinery, and to emphasise the fact that any just comparison of designs should be made under like conditions, and any other comparison, whatever its motive, is not only unfair but misleading. It will give me pleasure to show, possibly at an early date, the characteristics of the Richmond machines wound for storage battery work, and also the theoretical and brake curves of our heavier railroad and standard stationary machines.—Yours, &c.,

FRANK J. SPRAGUE.

New York, October 22, 1888.

[We think it probable that Mr. Sprague would have somewhat modified the tone of his opening remarks had he been aware of the fact that in whatever way Mr. A. T. Snell's experience may compare with that of American electricians, we know of no one in this country who has a more extended and practical knowledge of electric motors. –ED. *E.*]

CABLE TESTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to some remarks made by Mr. C. Bright at the recent meeting of the Society of Telegraph-Engineers, and published in *The Electrician* for November 16th, I should like to make some observations.

Mr. Bright's statement that 102·38 per cent. is at the present time "quite an ordinary conductivity for copper intended for telegraphic purposes" will come somewhat as a surprise to those engaged in the testing or manufacture of cables, as an average conductivity of 98 or 99 per cent. is generally considered an excellent result.

I quite agree with Mr. Bright that too much reliance should not be placed on his proposed method of calculating the temperature of a cable by the variation in its dielectric resistance, and of using the result as a check on the temperature coefficient of the conductor.

The said temperature coefficient might, indeed, come out somewhat higher (or lower) than that given for Dr. Matthiessen's standard; at any rate, it is not desirable that the "fresh standard" which Mr. Bright is anxious for, should have its temperature coefficient determined in this way.

The "practical examples" for calculating the effect of pressure on the dielectric resistance of a cable at depths of 2,000 and 3,000 fathoms are very curious; at first sight I thought that one or more of the "incipient faults" must have disappeared from the cables in sinking through the last 1,000 fathoms, as otherwise the increase of resistance due to pressure should come out directly proportional to the pressure.

According to the Paper of the late Sir William Siemens, referred to by Mr. Bright, it was to be expected that if the

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pressure at 2,000 fathoms increased the dielectric resistance by 123 per cent., the pressure at 3,000 fathoms would increase it by 184·5 per cent. (or by one and a-half times 123); but instead of that we are told that the increase jumps from 123 per cent. for 2,000 fathoms to 889 per cent. for 3,000 fathoms.

On looking into Mr. Bright's figures more closely the explanation of this discrepancy appears to be that in the example at 2,000 fathoms the pressure correction is applied to the resistance which the cable had at 75°F., whereas in the example at 3,000 fathoms the correction is applied, but only as regards the last 1,000 fathoms, to the resistance of the cable at 36°F.

The numerical results obtained and the inferences drawn are, in consequence, a little mixed.

I think the figures should stand thus:—

For 2,000 fathoms—

Resistance of cable at 36°F. in megohms per knot	6,737
Increase of resistance due to pressure = 123 per cent....	8,287
Corrected resistance	15,024

For 3,000 fathoms—

Resistance of cable at 36°F. in meghoms per knot	6,737
Increase of resistance due to pressure = 184·5 per cent.	12,430
Corrected resistance	19,167

Yours, &c., MEGOHM.

TELEPHONE CALL-OFFICES IN LONDON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To satisfy "A.S.T.E. and E.," and arrive at the facts in regard to the opening of the first telephone call-offices in London, I have examined the lists of subscribers issued by the United Telephone Company, and find the following announcement in the list dated August 1, 1881:—

"CALL ROOMS AND COMMISSIONAIRES.—Telephones have been fitted up at the following call rooms, where they are available, free of charge, for the use of all subscribers or their clerks, and where the general public are requested to inspect them and test the working of the system:—224, the United Telephone Company, 36, Coleman-street; 3553, office of the Corps of Commissionaires, 419A, Strand; 2561, 2562, Lonsdale Chambers, 27, Chancery-lane; 3044, 3045, Metropolitan District Railway Station, Westminster Bridge. Commissionaires are also stationed at these call rooms, and the services of a member of the corps can immediately be obtained on telephoning to any of the above numbers. Employers wishing to communicate with the adjutant of the corps on any matter of business can now do so from almost any part of the metropolis."

These rooms were used by the general public as well as by subscribers.

By August, 1881, four call rooms had therefore been opened in London; but, as a matter of fact, at least one, that at Coleman-street, had been in use for some considerable time before, and, for the special benefit of the legal fraternity, a call room was opened in the Temple as early as April, 1880.

In view of these facts, I cannot see how I am "basing on information that *must* be inaccurate;" or how, to quote your correspondent again, "it is matter of common knowledge in telephone circles that there was no call office in London prior to 1883." It appears to me that the common knowledge in telephone circles on the matter is proved to be common ignorance, and of a piece with other delusions which appear to be prevalent in regard to the United Telephone Company and its working.

"A.S.T.E. and E." states that in 1880 there was a call office in Edinburgh. I accept his statement unreservedly, but I may remark that it could not have been established by the existing telephone company—the National—for the simple reason that the National Telephone Company did not come into existence until March 10, 1881, *vide* the *Monthly Investment List* (Sept. 1888 of "Mr. Faithful Begg.")

In conclusion, I trust these remarks will definitely satisfy "A.S.T.E and E." I have no wish to discuss the matter further.—Yours, &c. J. MUNRO.

November 19, 1888.

ON THE ACTION OF LIGHT ON STATICAL CHARGES.*

BY F. NARR.

The author proposes to measure the rate of leakage of one plate of a condenser when charged with positive or negative electricity, and to observe if there is any difference in the rate according as the plates are illuminated or in the dark. The illumination was by means of a magnesium lamp, and the smoke caused by it was removed from the condenser as far as possible, so that the magnesia dust should not affect the rate of leakage. The room at his disposal for the experiments did not allow of an electric lamp being used.

The condenser had two parallel circular plates, separated by an air space of 2 centimetres. The plates had their planes vertical, and one (which he calls the "inner" plate) was usually charged and connected to the electrometer, the other ("outer") insulated or put to earth. The connections could be made almost instantaneously by suitable mercury cups.

(1) The light was placed in the plane midway between the two plates, and screened off. The outer plate being permanently insulated, the inner one was charged by connecting to the previously charged electrometer, and two minutes after this connection was made the charge was measured. It was again measured at the end of another two and four minutes respectively. The experiment was performed again with the light screen removed for half a minute between the first and second readings of the charge. No difference was found in the rate of leakage between the dark and illuminated condition of the plates either for a + or − charge of the inner plate.

(2) The outer plate was put to earth just before the first reading of the charge. The rest of the experiments as before. Again no effect was observed due to the light.

(3) The light as before, but left shining on the plate for two minutes, outer plate put to earth before reading charge first time. Still no effect due to light could be observed.

(4) The light in same position as before. The operations as follow:—Charge inner plate, outer one insulated. Connect electrometer to inner plate.

After 2min. read charge.
,, 3½min. begin illumination.
,, 4min. put outer plate to earth and read charge.
,, 4½min. cut off illumination.
,, 6 and 8min. read charge.

There was no effect seen in this case, in which the outer plate is put to earth *during* the illumination. The remaining experiments were made on the inner plate of the condenser alone, which was then freely charged with electricity, the outer plate being removed. The light was placed 19 centimetres from the centre of the plate and on its axis. The plate was charged and allowed to stand two minutes, charge read and illumination commenced, at end of 2½min. illumination stopped, charges read at end of 4, 6, and 8min. The experiment was repeated in the dark, and the result shows that the illumination produces an apparent discharge of the plate, which is of greater amount in a positively than in a negatively charged plate.

An experiment repeated with light 22 and 25 centimetres away from plate showed that the apparent discharge falls off rapidly with the increased distance of the light, but is always less for a negative than a positive charge.

The next experiments were made to ascertain the effect of long and short duration of illumination. The plate being 19 centimetres from the light the losses in 4min. were as follows:—

Duration of illumination.	Loss of charge in 4min. +	−
5 sec.	0·0367	0·0294
30sec.	0·0887	0·0661
60sec.	0·3948	0·0839

The author concludes by pointing out that the effects cannot be considered as due to dust from the lamp, because the rate of discharge with the plate in the dark was far less than when illuminated, even though the air was dusty with the magnesia from the lamp in each case.

* Wied. Ann., N.F. XXXIV., p. 712. (Abstract made by Dr. J. L. Howard, Demonstrator of Physics in University College, Liverpool.)

BOOKS, &c., RECEIVED.

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COMPANIES' MEETINGS.

Eastern Telegraph Company (Limited).

An extraordinary general meeting of the members of this Company was held at Winchester House, 50, Old Broad-street, yesterday (Thursday), to consider resolutions increasing the Ordinary share capital of the Company from £3,800,000, to £4,000,000, by the creation and issue of 20.000 new shares of £10 each. Sir John Pender occupied the chair.

The SECRETARY (Mr. Geo. Draper) having read the notice convening the meeting,

The SOLICITOR (Mr. Burt), at the request of the Chairman, read the following resolution which it was intended to submit to the meeting:

"*That the Ordinary share capital of the Company be increased from £3,800,000 to £4,000,000 by the creation and issue of 20,000 new shares of £10 each.*

"*That such new shares shall rank for dividend equally with the existing Ordinary shares as from 30th September, 1888.*

"*That such new shares be in the first instance offered at the price of £14 per share (£2 per share premium) to the members of the Company registered on the 22nd November, 1888, as holding 10 or more Ordinary shares—holders of from 10 to 20 Ordinary shares to be entitled to one new share, and holders of more than 20 Ordinary shares to be entitled to one new share for every complete 20 Ordinary shares held.*

"*That all new shares not accepted by the members entitled thereto and £2 per share duly paid thereon, be allotted and disposed of by the Board of Directors as they think expedient.*

"*That the amount of the new shares and premium be payable as follows:—£2 per share on or before the 2nd December, 1888; £5 per share on or before the 15th December, 1888; £5 per share on or before the 15th January, 1889.*

"*That upon completion of the payments the premium of £2 per share be carried to the general reserve fund, and the share certificates issued.*

"*That the Directors may require interest at £10 per cent. per annum on any instalment (after the first £2 per share) in arrear.*

"*That, subject as aforesaid, the details, terms and conditions of the issue be such as shall be determined by the Board of Directors.*"

The CHAIRMAN: You have heard the resolution read, but before I ask you to approve of it I think it will be interesting to you, and only right for you to know, the reason why we ask for this increase of capital. The last time that we called upon the shareholders to sanction an extension of capital was in 1872. At that time there was an amalgamation of different companies. There were four or five in number, which were put together under the title of the Eastern Telegraph Company. As an instance of the growth of this Company, the following figures may prove interesting:—On the amalgamation in 1872 the Eastern Company owned 8,862 miles of cables, and owned and rented about 1,200 miles of land lines. They had 24 stations and two cable repairing ships. The capital was £3,397.000. The gross revenue was about £376,922 per annum. That was in 1872. At March last the total capital was £5,900.000, and the gross annual revenue £650,971. The cable mileage was 22,405 miles, and with the Eastern and South African Company's existing cables and the extension to Loando the total will be 29,108 miles. The increase in the capital issued since the amalgamation in 1872 is therefore £2,503,000, and in addition over £700.000 has been applied from the reserve fund, and a new ship costing over £45,000 has been paid for out of the ships' fund. The additional capital was raised as follows:—£403,000 by Ordinary shares, £700.000 by Six per Cent. Preference shares, £232,000 by Six per Cent. Debentures, £650.000 by Five per Cent. Debentures, and £518,000 by Four per Cent. Stock. £682.000 has also been issued at 4 per cent. to replace the Six per Cent. and Five per Cent. Debentures for a like amount, so that out of the 2½ millions of new capital raised since the amalgamation £1.200.000 bears only 4 per cent. interest, effecting a saving to the Company of £9.140 per annum in interest. The remaining £200.000 Five per Cent. Debentures will be replaced in 1899 by the issue of a like amount of Four per Cent. stock. With the new capital raised and the contributions from reserve and revenue the following work has been done:—Duplicating (839 miles) the cable between England and Lisbon, and extensions in Levant; completing the Levant extensions; the Sardinian cable, for which we receive a subsidy of £4,400 per annum; duplicating Suez-Aden and Aden-Bombay cables; Marseilles-Bona and Bona-Malta cables; purchase of Black Sea Company; connecting Cyprus with Alexandria; purchase of South African shares; triplicating the Red Sea, Malta, Tripoli, and Greek cables (and we receive a subsidy from Greece of £6.500 per annum); purchase of Mediterranean Extension Company; purchase of shares in the African Direct Company; and duplicating the Portheurnow and Malta cable and extension to Zante. That shows what we have done with the money, and I will now show you the increase that has, so far, taken place in the number of our stations, as compared with the number that I stated first. We have got in England 7, Scotland 1, France 3, Spain 3, Portugal 5, Egypt 5, Greece 10, Turkey 13, India 1, Austria 2, Cyprus 7, Russia 1, Morocco 1, Barbary 1, Gibraltar 1, Malta 1, Perim 1, and Aden 1. That makes a total of 64, so that we have increased the number of our stations to that extent from 24. We have at the same time added three ships to our fleet. That shows you, gentlemen, the marvellous growth in the last sixteen years in our system, and that growth has been largely facilitated by our keeping ahead of the requirements of the public. Our asking you to-day to come and sanction this increased capital is to enable us still further to secure the interests of this Company and also to secure permanency to the telegraphing public. The object of our asking you to raise this £200.000 is to duplicate the South African system which we took in hand in 1879. At that time the whole question was before the shareholders. When we first made our proposal in connection with the South African Company there were a great many people who did not believe that that system would pay. Your Board held a very different opinion, and we went at it with a will, determined, as far as we could, to carry it through. We went to considerable expense in the original construction of the Company. We took a large interest in it, and taking that interest in it we believed, if it were successful, that eventually it would be an enormous benefit to this Company. At the time, however, there was so much said as to the propriety of the Eastern Company taking the whole of the responsibility, that other companies shared the risk with us, and at that time, when it was brought before the Board in July, 1879, the Board considered it inexpedient that the Eastern Company should take the entire responsibility of the undertaking. In the Directors' report to the general meeting of the 14th July, 1879, we said:—"As the Board considers it inexpedient that the Eastern Company should take the entire responsibility of this undertaking, it is intended to form a separate Company, to be called the Eastern and South African Telegraph Company, with a share capital of £400.000, and Mortgage Debentures for £600.000; but as the entire management and working of the cables will be in the hands of the Eastern Company, and the traffic will pass over their wires from Aden, the new lines will practically be an important addition to this Company's system, and in consideration of the advantages which will be derived therefrom it has been agreed, subject to the approval of the shareholders, that £200.000 of the share capital, and if necessary a portion of the debentures, shall be subscribed by this Company, and a rebate be given upon the traffic obtained by the Company from the new lines. As the debentures are to be paid off by means of an accumulative sinking fund, the Eastern Company will thus obtain half the reversionary property in the new lines, whilst the Company's holding in the share capital will give them an effective control." You will see from these remarks that we exercised caution and prudence in going into this South African Company. During that time the South African Company has grown to very large proportions. What with the diamond and gold speculations at Zanzibar the traffic has been good, so much so that it became absolutely necessary that that system should be duplicated, and therefore, instead of duplicating the system by which we approach the Cape at the present time, namely, by the East Coast, the Board resolved to carry a line by the West Coast. The South African Company are to carry out that line: but the South African Company being practically the property of the Eastern Company, the benefits derived will of course accrue to the Eastern Company. Before, however, we decided to take this step—a step which is desirable for the security of the traffic, and to give something like permanency to telegraphic connections which exist at the present time, and which are so important to the public—before we took that step different companies had been formed in connection with the West Coast of Africa. One of those companies is the African Direct Company, of which we have practically the management—that is, so far as all practical purposes are concerned—in our own hands. There is another company, called the West African Company, and we have practically secured that, its management being also in our own hands. Therefore, by laying a new line from the Cape to connect with this existing system, we get an alternative line from London direct to the Cape, so that we cut both ways. We encircle Africa, and at the present time, when all the different Governments of Europe are looking at this dark country with the view of developing it, as it has always been our policy to be ahead of requirements, the telegraph will by our proposal be there when they want it to assist in the development, and there is no system that tends so much to promote and develop commerce for the interests of a people as the telegraph. I think I have now shown you that we are in a position of controlling Africa by our system. The present scheme is to be carried out on the principle of shares and debentures. We ask you now to increase the capital of the Eastern Company by £200.000. That money is to be expended to purchase shares which the South African Company are going to issue, and we become practically proprietors of the South African system. £300,000 of debentures which are also required—because the whole system will require half a million of money to complete it—we shall issue to our own shareholders *pro rata*. Those debentures are a good property. They are in demand, and probably stand at as high a premium as any security of an equal kind stands at present in the market. Therefore, what we are asking you to do is simply to give us the power to increase the value of your own property. When these concessions expire, we shall find ourselves at the end of ten years, and again at the end of twenty years, in possession of this vast system to South Africa, profitable, and I believe increasingly so, and we shall find ourselves in possession of it at a comparatively nominal value. We shall hold the shares, but all the debentures by that time will have been paid off, so that we hold all that extended system simply for the share capital which we shall hold at that time. I think I have now given you a fair statement of the facts, and I think you will agree with me that the policy we are pursuing of keeping the South African Company entirely in our own hands is a good one. The having the management entirely in our own hands of the existing system to the West Coast gives a security to the shareholders of a permanency to the telegraphic system, such as it would have been impossible to get had the thing been in different hands. As you know, a concentrated management in telegraphs is an absolute necessity, in order that the advantages of speed may be fully realised. If telegraphic communications were to pass through different hands, and to be dealt with by different companies, the delays would be such as to make telegraphing almost impossible. As it is, by our system, an interruption occurred the other day on one of the sections, which was then in other hands, and the telegrams were occupying four days as against two hours when our system was in complete working order. You can see the advantages, therefore, which

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are obtained by this concentration. On these grounds I ask you to-day to approve of the resolution which has just been read to you, and which I now move, holding that it is a safe and sound movement on the part of the Eastern Company. If anyone has any question to ask before I put the resolution I shall be happy to reply to him.

Lord TWEEDDALE seconded the resolution.

In reply to a few questions that were asked,

The CHAIRMAN said that the Directors had worked out the figures, and found that after giving every shareholder his proportion of shares as set out in the resolution there would be 1,900 shares left, and as they had 1,700 shareholders holding under ten shares each, they proposed, in order to encourage the shareholders, which they were desirous of doing whenever they could, to make an offer to those who held less than ten shares, or even one share. The debentures they proposed to offer to the shareholders of the South African in common—£300,000 debentures *pro rata* if they chose to take them at 4 per cent. and at par, although they were at a good premium at the present time. A holder up to twenty shares would, according to the programme, receive one share—one share for every twenty shares. He then put the motion, which was carried unanimously.

A vote of thanks to Sir John Pender for presiding, and to the Directors for the able way in which they managed the affairs of the Company, was then proposed, seconded, and carried unanimously.

The CHAIRMAN, in reply stated that nothing was so satisfactory to him and the Directors as to have the confidence and approval of the shareholders. The Company had grown during the last sixteen years by leaps and bounds, maintaining a fair dividend during that period, and conferring enormous benefit on the public generally. He saw the Company growing stronger and stronger every day.

The proceedings then terminated.

South of England Telephone Company (Limited).

An extraordinary general meeting of the South of England Telephone Company was held at 50, Old Broad street, yesterday (Thursday), Mr. D. O. Bateson presiding, for the purpose of considering and, if approved, of passing the following resolutions :—

(a) *That the following words be added at the end of Article 11 of the Articles of Association of the Company :—"Provided also that no call shall exceed one-fourth of the nominal amount of a share, or be made payable within two months after the last preceding call was payable."*

(b) *That Article 15 be repealed, and the following Article be substituted in lieu thereof :—"15. The transfer of any share in the Company shall be by deed or deeds on the usual common form of transfer. There shall be paid to the Company in respect of the registration of any transfer or transmission such fee not exceeding 2s. 6d. as the Directors deem fit."*

(c) *That the words "not fully paid up" be inserted after the word "shares" in Article 17.*

(d) *That the words "not fully paid up" be inserted after the words "the Company shall have a first and paramount lien on all shares" in Article 21.*

(e) *That the word "tenth" be substituted for "fifth" in Article 40.*

(f) *That all the words after "claimed" be omitted from Article 98.*

Mr. FRED. L. ROBINSON (the secretary) read the notice calling the meeting and the above resolutions.

The following is a circular issued by the Directors :—

"In accordance with the suggestions made at the last annual meeting, and the wish since expressed by influential shareholders, the Directors have taken steps to obtain from the committee of the Stock Exchange a quotation for the shares of the Company. There are a few minor points in the Articles of Association which do not accord with the rules of the Stock Exchange, and consequently require to be altered; this can only be done at an extraordinary general meeeting of the Company.

"During the past half-year trunk lines have been completed between Canterbury and Dover, Lewes and Eastbourne, Wellingborough and Kettering, and an exchange has been opened at Kettering.

"At the 31st October last 1,629 exchange lines and 437 private lines were completed, and 64 exchange lines and 13 private lines were in course of construction. The progress made as shown by this statement is considered satisfactory by the Directors.

"The dividend on the Six per Cent. Preference Shares up to the 31st ultimo has been paid.

"Comparative Statement of Exchange and Private Line Business.

	Exchange.	Private.
April 30th, 1886	687	248
April 30th, 1887	1,130	348
October 31st, 1887	1,316	373
April 30th, 1888	1,521	386
October 31st, 1888	1,693	450"

The CHAIRMAN said that the shareholders were all well aware of the object for which they had been called together that day, it having been fully stated in the circular sent out, and he did not therefore wish to detain them with any lengthened observations, but would just like to know whether they would have the alterations submitted each as individual resolutions, or would take them *en bloc* in one resolution (a Voice: "Take them *en bloc*"). They were of a very trivial nature, and he thought they had already acted up to them. The first alteration was in Article No. 11, viz., "Provided also that no calls shall exceed one-fourth of the nominal amount of a share." Well, they had never made a larger call, he believed, than one-tenth.

The SECRETARY said 10s.

The CHAIRMAN (continuing) said further that no call should be made payable less than two months after the last preceding call was payable. Well, the calls had been made at much longer intervals than that; the first was made after an interval of 15, and the second after an interval of 13 months, and there was, therefore, no likelihood of any difficulty arising in the future in the matter of calls. With respect to the next alteration, Article 15 was repealed altogether, and a fresh article substituted in its place. He might state that they had always used the common form of transfer, although not previously compelled to do so. The new article, however, compelled its use, repealing the power previously possessed to use other forms. They had always charged 2s. 6d. for transfers, so that part of the article remained precisely the same. The next alteration had reference to any lien the Company might have upon shares, and provided that the lien should only apply to such shares as were not fully paid up. Then in Article 40, which provided that the Directors should whenever they thought fit on a requisition in writing, signed by at least one-fifth of the capital, call a special meeting, an alteration had been made reducing the number that could call a meeting to one-tenth, so that in the future a smaller number of dissentients could, if they wished, have a meeting. He moved formally that all these alterations should be passed.

Mr. ALEXANDER MACGREGOR seconded the motion.

Mr. BEVIS: Before you put it, Mr. Chairman, do I understand that if the shares had been fully paid-up there would have been no necessity for these alterations?

The CHAIRMAN: That would have done away with them all.

A SHAREHOLDER asked whether there was any intention at present of calling up the balance of the money and making the shares fully paid-up?

The CHAIRMAN said they would call it up as fast as they wanted it, but they had no wish to pay 6 per cent. on money they did not require.

Mr. BEVIS: I wish you had sufficient business to make you do it (hear, hear).

The resolution was then put and carried.

The CHAIRMAN: We shall be obliged, in accordance, with the Statute, to call another meeting within a short time to confirm this resolution. It will be held this day three weeks at the same time and same place. That, gentlemen, is the whole of the business. We are very much obliged to you for your attendance, and we are glad to have such a unanimous meeting.

A vote of thanks to the chairman terminated the proceedings.

PACIFIC CABLE CONFERENCE.

A conference of the public interested in the telegraphic system between Great Britain and her Australasian dependencies was held yesterday (Thursday) in the Cannon-street Hotel, to consider the laying of a Pacific cable from Canada to Australia.

The Right Hon. the EARL of WINCHILSEA occupied the chair, and in opening the proceedings said he felt it a very high honour to be called upon to preside over such a conference as that, and he was very glad to see such a large and representative gathering assembled on the occasion, as showing how great an interest was taken in the subject by busy City men. He would not take up very much of the time of the meeting as Chairman, because what they desired was to obtain an independent expression of opinion from them as commercial men whether or not the time had not arrived—whether, indeed, it was not high time—that something was done to improve the telegraphic communication between this country and the Colonies of Australasia. But one or two words he would like to say as to one, if not more, of the many aspects of that great Imperial question. First of all let him say that they were assembled there simply as men of business to set forward their own interests as traders. They were not there to attack other people; they were not there even to fail to realise or to recognise the great debt which they owed to those who had been the forerunners in the matter of telegraphic communication. They were met simply to ask themselves, and to answer the question, whether the means of communication which at present existed were sufficient, whether they were safe, and whether they were as cheap as they ought to be? With regard to the present means of communication, he thought they could hardly be called cheap; he should say almost that the word prohibitive would be more applicable to the tariff which at present obtained between this country and Australasia. The rate of 9s. 8d. must lead, if not to a prohibitive, to a very restricted intercourse indeed. It led, as he knew perfectly well—having had relations out in the Colonies himself—to that sort of intercourse which made people compress their messages into such a small space that very often when they arrived at the other side of the world they were totally unintelligible. As regarded the second essential, its continuity, there again he must point out that no less, he thought, than three times during the last four months had telegraphic communication between this country and Australasia been entirely interrupted. Then again, with regard to its safety, they had, of course, to consider that there were only two states in which the world could be—one was peace and the other was war. With regard to the safety of their existing lines of communication in time of war, it was not too much to say that they would be absolutely defenceless, and without the means of defending them if they were involved in a great European war. The fact that the present lines of communication passed through Suez rendered them of course exceedingly liable to any interruption from that cause. Egypt had been the battle-field of the world in other generations, and might be in their own, and nothing was more certain, he thought, than that if they were

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involved with any great European Power in a war in Egypt that means would be found to cut entirely the communication, which it would be impossible for them to prevent, and they would possibly be placed in the position of being for six weeks cut off entirely from Australia. That was a contingency which, from an Imperial point of view, they could not possibly contemplate without the greatest apprehension. In so far as those three requisites—cheapness, continuity, and safety—were concerned, he thought the remarks he had made with regard to their present system would probably meet with the approval of the Conference. With respect to the proposal made to them it was simply this, that a line of cable should be laid from Vancouver to Australia, touching at Hawaii, Fanning Island, Samoa, and Fiji. Of course, the existing lines of communication between this country and Vancouver were very strong and dependable. It was fair to say that from this country there were so many lines across the Atlantic at the present moment that, having in view the interests that the United States must have, as well as themselves, in maintaining that communication, it was all but impossible that it should ever be destroyed between the two countries. Then we had entirely on British soil the Transcontinental line of wire through Canada, which landed them at Vancouver, and thence across the Pacific at unknown depths: but with regard to the subject of the depth at which they could lay a cable across the Pacific he would content himself by saying that the question had been referred to experts, and their consensus of opinion was that it was a perfectly practicable route, and he would remind them that there was a cable in existence to Pernambuco which was only 200 miles less in point of length. The experience of deep-sea cables was this, that they were very much less liable than were cables in shallow seas both to the attacks of insects on the one hand, which often destroyed cables, and to the action of the currents on the other, which caused considerable attrition at the bottom of the sea. The bottom of the Pacific was, generally speaking, except at the equator, where the cable could easily be protected, composed of a kind of soft mud which was very favourable to the laying of a cable. At the bottom of the sea at great depths the water was colder than in shallow waters, which was also favourable to the life of a cable, and, as he had said, there were no currents there, while the existence of animal life at the pressure of great depths was improbable, if not altogether impossible. Another point in favour of a deep sea cable was of course its great safety in time of war. It would be extremely difficult, if not impossible, to destroy a cable at the depth at which they proposed to lay it, and therein would lie a very great Imperial safeguard. There had been a printed letter circulated extensively that morning by those who represented the Eastern and Eastern Extension Companies, and he thought it would only be right that some answer should be made to that letter on behalf of the Company which had brought them together that day. He would not further refer to it now, but he would before the proceedings closed ask his brother, Mr. Harrold Finch Hatton, to go through that letter *seriatim*, and give such a reply to it as his experience would enable him to do. It remained for him now to point out to them that a very great advantage would be gained by a reduction of the tariff from 9*s*. 8*d*. to 4*s*., as they would easily comprehend. It would revolutionise entirely the business arrangements and the way in which they would be conducted between England and the Colonies, very much to the advantage of business. It would probably lead to a very large development of the trade, which was quite ready to spring up between the western shores of the Pacific and their colonies in Australasia which would be a British trade. Therefore, it was one in which they would take an interest, and from which they would look for a great increase of traffic on their line, which would make it remunerative. There was one point which had been misapprehended with regard to the guarantee that had been asked for from the Governments. That guarantee was not in the nature of a subsidy, but merely a guarantee that the Governments would, in a proportion arranged between themselves, guarantee to use the cable to the extent of £75,000—that was to say, they might have a *quid pro quo* by using the line to that extent, which they would apprehend was a very different kind of guarantee from that which agreed to pay so much money without getting the benefits from it which they had a right to expect. With regard to the Imperial nature of the problem, they all knew how trade followed the flag. Figures told them that their trade with Australia was about £8 per head, while that with the United States and other English-speaking people was only 8*s*. a head. Therefore, everyone would agree with him and say that they ought to encourage that trade. That would be facilitated by a line of communication laid almost solely—he ought to except Hawaii, which was under the joint protection of themselves and the United States—within the control and the limits of the British Empire. In the event of war it would be possible to land a great number of troops at Vancouver, and to draw them from thence to India and Australia, and in a shorter time than could possibly be done supposing their communications through the Suez Canal were interrupted, than had they to send them round the Cape. That was a great factor in the Imperial problem, to which he drew their attention. The whole scheme involved this. It involved two if not more lines of subsidised mail steamers, which would be armed cruisers carrying the mails in the Pacific, and a telegraph line to correspond with their line, and in that way he thought they might say that England would sufficiently protect her interests in the Pacific. There was great competition going on at the present moment, he believed, between Canada and the United States as between two points, San Francisco and Vancouver, to determine whether the Pacific trade should concentrate upon San Francisco and be carried by the United States lines across towards Europe, or whether it should concentrate itself at the British port of Vancouver and be carried by the Canadian Pacific to this country. Now they would follow him when he said that Canada, having made, after great exertions, the great Imperial route of the Canadian Pacific Railway, which had cost 57 millions of money, in order to make one of the great piers of the arch of communication which ought to join England and Australia, deserved well of the mother country. She was deeply interested in this scheme, and he was very glad to know that he would have the pleasure of calling on Sir Donald Smith to move a resolution in favour of it. The Australian Colonies had not been behindhand either in the interest which they manifested in the scheme. It was a most significant fact that this was probably only the one great public question on which Victoria and New South Wales were really agreed, and therefore he thought it was a good omen for the success of the undertaking that the Australian Colonies had taken it up as warmly as they had done, and that Canada had shown so great an interest in it. His hearers, who lived in the great centre of British trade, ought not to be behindhand in recognising from their point of view its immense importance, as had been freely done in Canada and Australasia. If the project were carried out it would be for them to say what would be its importance from a commercial point of view. They should undoubtedly then be put in possession of a means which would open up the Pacific as it had never been opened to British trade and British influence. They should divert, he believed, the main volume of traffic to the British instead of to the American centre, and they should also be in possession of a line of telegraphic communication which would be at once a second string to their bow, and also a cheap, safe, and continuous line of communication between England and her great dependencies. He felt that he had detained them at greater length on the subject than he ought to have done; but the fact that they had gone there in such large numbers proved to him the deep interest which they took in it. He had great pleasure in calling on Sir Donald Smith to propose the first resolution.

Sir DONALD SMITH moved the following resolution:—

"*That in view of the unsatisfactory state of the existing telegraphic communication between Great Britain and Australasia, this meeting most strongly approves of the proposal of the Pacific Telegraph Company (Limited), to lay a cable across the Pacific Ocean from Vancouver Island to Australia, touching at Hawaii, Fanning Island, Samoa, Fiji, and New Zealand, and to reduce the tariff from Great Britain to Australasia to 4s. per word, and that this meeting, believing that the laying of such a cable would be of great benefit to commerce in time of peace, and a safeguard to Imperial interests in time of war, trusts that Her Majesty's Government will do all in their power to facilitate the laying of such a cable, especially by obtaining the necessary soundings with as little delay as possible.*"

He said it was gratifying for him to be present to advocate, as far as he possibly could, an enterprise which had been so ably placed before them by the noble Chairman, and which he believed to be worthy of every support that could possibly be given to it by the commercial community of London, by the people of England, and by the Colonies, as he believed it to be in the true interests of the Empire at large. He believed the scheme would be of considerable advantage to Great Britain as well as to the greater Britain.

Mr. DOXATT (of the firm of Messrs. Dalgety and Co.) seconded the motion, and spoke of the inconvenience to which commercial men had recently been put owing to the recent interruptions to the existing Australian cables.

Mr. BLACKWOOD, as an Australian born, advocated the proposal as of considerable importance in connection with Imperial federation.

Mr. J. McEWIN trusted that those connected with the new scheme would not trust to the Governments for help. He considered it was a most important scheme, going as it would across British territory entirely, and, in his opinion, there was no physical difficulty at all in connection with the construction of the cable.

Mr. WESTGARTH said he had just returned from Australia, and not having been there for many years he had been struck with the enormous progress which had been made in the Colonies.

The CHAIRMAN put the motion, which was carried unanimously.

Mr. HARROLD FINCH-HATTON said that the presence there of so many business men in the busiest part of the day showed the great interest taken in the proposal. He then referred to a circular which had been issued by the Eastern Telegraph Company, and replied at length to the statements contained therein. They had asked for Government support to the scheme, but were met by the statement that it would not be fair to support a scheme which came into competition with the existing cable system. There might be something in the objection if the proposed cable were to be laid exactly over the ground occupied at present by the Eastern Extension Company, but such was not by any means the case. He submitted that they were deserving of every support from the Governments for several reasons, and the whole question was purely one of national existence. He maintained that the existing system could not in fairness be described as under British control, passing as it did through different foreign countries, and said that the proposal of the Pacific Cable Company in connection with the depth at which they proposed to lay their line was one of the greatest possible safeguards in connection with the life of the cable. He then spoke of the interruptions to the present cable and the inconvenience and dangers thus incurred. It was perfectly evident that some sort of sacrifice must be made by the various parties interested in the proposal in order to secure for themselves mutual advantages, which they could not expect for nothing, and he maintained that if the British Empire, by an outlay of £75,000 a year for 25 years, a large portion of which would return into the public exchequer in the form of free Government messages, got the advantages he pointed out it would have received uncommonly good value for its money. Whether or not, however, a guarantee were given, he was convinced that the projected cable would be laid, so strongly did the Colonies support it.

On the motion of Mr. BLACKWOOD, seconded by Sir DONALD SMITH, a vote of thanks to the Chairman was passed.

The CHAIRMAN, in reply, expressed a hope that their efforts that day would be the means of forging one other link in the chain which bound the mother country and the Colonies together.

The proceedings then terminated.

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THE PACIFIC TELEGRAPH SCHEME.

The following letter has been addressed to the editors of the leading daily papers:—

"Sir: The circular sent out by the Pacific Telegraph Company, convening a meeting, to be held on the 22nd instant at the Cannon-street Hotel, to consider and pass a resolution in favour of their proposal for laying a cable from Canada to Australia, contains the following statement, namely, that 'the extremely unsatisfactory state of the existing cable communication between England and Australasia is injurious to trade, and would be a source of great danger to imperial interests in time of war.'

"In thus endeavouring to disparage the existing communication, the Pacific Telegraph Company doubtless hope to further the objects they have in view, but as the statement is most exaggerated and misleading, my directors trust you will find space in your valuable paper for the following remarks, in order that any false impressions created in the minds of those attending the meeting may be removed, and that the telegraphing public may have both sides of the question before them.

"The existing communication with Australia was established by the Eastern Extension Company in 1871, without subsidy or assistance of any kind from the Colonies or the Imperial Government, and subsequently, when the importance of telegraphy became more fully realised, and a duplicated system a public necessity—not because a single line was unequal to the transmission of the traffic, but in order to provide against the interruptions inseparable from a single line of cables—the colonies of Victoria, New South Wales, South Australia and Western Australia agreed to give the company a subsidy of £32,400 per annum for 20 years, to enable it to duplicate the cables between India and Port Darwin. Since then the telegraphic communication has been very seldom interrupted, a result due to the duplication, and in some sections triplication, of the cables, and to the fact that they are laid for the most part in shallow water, and are consequently repairable at almost all seasons of the year.

"Unfortunately, during the past few months the communication has been thrice interrupted through exceptional circumstances, and the public, not adequately appreciating the enormous difficulties and expense inseparable from the efficient maintenance of submarine telegraphy, have made little or no allowance for the same. On the first occasion both the Java-Australian cables were suddenly and simultaneously interrupted in deep water through volcanic disturbances, and the two subsequent breakages were in connection with the renewals of portions of the cables where they were found to be on bad ground and in dangerous proximity, owing to the strong currents off Java having drifted them together.

"The total interruptions, however, since the communication was duplicated in 1880, including those above mentioned, have aggregated only forty-one days, averaging less than five days per annum, a result that will bear favourable comparison with the working of any other submarine system in the world.

"In order, however, to further strengthen the system, the company are about to lay a third cable from Java to Australia, which, by working with the Western Australian land lines, will give the Colonies the advantage of an alternative land connection *vid* Perth and Eucla to the existing overland line between Port Darwin and Adelaide. Consequently the Colonies will be provided with a complete and efficient telegraphic service by the existing system, not only equal to the transmission of a much larger traffic than it now carries, but enjoying the immense advantage of being under English control and worked by English operators throughout its whole length.

"My directors would therefore submit that the existing company, as the pioneer of telegraphic communication with Australasia, is entitled to consideration at the hands of the Colonies.

"With regard to the reflections made by the Pacific promoters as to the insecurity of the existing communication in time of war, I am directed to point out that while the route between Australia and Java and Europe is incomparably the most secure and easily protected in time of peace, it would be the most surely and easily safeguarded in time of war, inasmuch as it is one of the sea routes most frequented by the mercantile marine, and would therefore be the special object of the vigilance and care of the Royal Navy.

"On the other hand, it would be impossible for the British Government, however anxious to do so, to provide adequate protection in the case of cables laid across the Pacific, far away from the routes used by commercial ships, and at immense distances from coaling stations, and, moreover, a single line of cables, consisting of long stretches across such enormous depths as those recently reported to have been found by Her Majesty's ship "Egeria" off Fiji, namely, 4,295 fm. and 4,430 fm. (five miles deep), and terminating on coral reefs, would inevitably be exposed to frequent interruption, which would render its maintenance most costly and difficult. It should also be borne in mind that the Canadian Pacific land line, passing as it does through exposed and stormy regions, would also at certain seasons of the year be very difficult to maintain.

"The question, however, is, are the public prepared to find the necessary money for a Pacific line? If so, they must make up their minds to an expenditure of nearly four millions sterling for a duplicated service. This large expenditure, however, is in no way justified by the existing traffic, which only gives a moderate return upon the capital already invested, and, consequently, the additional outlay would prove altogether unremunerative.

"The proposal made by the Pacific Telegraph Company that Government traffic should be guaranteed to the amount of £75,000 per annum for twenty-five years is not so favourable to the Colonies as it would at first sight appear, as the whole of the traffic at present exchanged by the Imperial and Australasian Governments represents less than £16,000 per annum, and consequently the Governments would have to extend their expenditure by about £60,000 per annum to make up the amount of guarantee.

"If, however, the Colonies are in earnest in their desire to have cheap tariffs, the object can be easily attained by adopting the guarantee proposal submitted by the Eastern Extension Company to the Imperial and Australasian Governments last year, by which the Colonies might make the tariff any figure they please, provided the Eastern Extension and its associated companies were guaranteed three-fourths of their present moderate earnings from the Australasian traffic, the companies accepting the remaining one-fourth of the guarantee risk. This would give the Colonial Governments full control over the tariffs, and, in our opinion, enable them to establish a cheaper rate on more favourable conditions than could be obtained in any other way.—I am, sir, yours, &c.,

"F. E. Hesse, Secretary,
"The Eastern Extension, Australasian and China Telegraph Company (Limited).
"Winchester House, 50, Old Broad-street, London, November 21."

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

15,801. A. B. Blackburn. London. An improved joint for electric light fittings. November 2, 1888.

15,865. C. J. Munier. London. Improvements in multiple printing telegraph apparatus. November 2, 1888.

15,868. A. Winkler, A. Kuhnt and R. Deissler. Berlin. A process of reduction of aluminium by electrolysis. November 2, 1888.

15,869. C. B. Harness. London. Improvements in electro-magnetic induction apparatus. November 2, 1888.

15,877. E. Rousseau. Leyton. Pocket or portable secondary batteries or accumulators. November 3, 1888.

15,910. L. Kayser. London. Improvements in galvanic batteries. [Date applied for under Section 103 of the Patents, &c., Act, 1883, April 13, 1888.] November 3, 1888.

15,915. F. V. Anderson. London. Improvements in electric arc lamps. November 3, 1888.

15,921. A. Siemens. London. An improvement in electric railway signals. November 3, 1888.

15,928. E. Duvalle and A. Dousson. London. Improvements in electrical motive power engines. November 3, 1888.

15,935. D. Latchinoff. London. Improvements in the production of oxygen and hydrogen in large quantities by means of the electrolysis of water, applicable for ballooning and other uses. November 3, 1888.

15,947. C. B. Burdon. Liverpool. Improvements in systems of electric traction for railways and tramways. November 5, 1888.

15,949. T. Pease and C. B. Burdon. Liverpool. Improved methods of applying electricity to a general system of traction. November 5, 1888.

15,961. T. Field, Jun. London. An improved electrical fabric for medical purposes. November 5, 1888.

15,989. B. J. X. Gosselin. London. Improvements in dynamo-electric machines and electro-motors. November 5, 1888.

16,001. J. Gardner. Preston. Repeating railway signals on a locomotive engine by the aid of electricity. November 6, 1888.

16,005. A. G. Burrell. Sheffield. Utilising existing telephone line wires for clock synchronising or controlling purposes. November 6, 1888.

16,025. S. Bunting. Dublin. Improvements in automatic measuring, supply and delivery of air, gas, electricity and like force; also liquids, by the introduction of a coin or any given weight. November 6, 1888.

16,047. W. P. Thompson. Liverpool. Improvements in magneto-electric railway signals (The Pennsylvania Steel Company, United States). November 6, 1888.

16,048. W. P. Thompson. Liverpool. Improvements in or relating to secondary or storage batteries (C. H. Thompson, United States). November 6, 1888.

16,054. C. Wells. London. An improved apparatus for the delivery of electricity. November 6, 1888.

16,099. C. M. Dorman and R. A. Smith. Manchester. Improvements in the construction of electrical switches, cut-outs, ceiling and wall connectors. November 7, 1888.

16,129. J. E. Lansard. London. An improvement in the contact makers of electrical alarms for doors and windows. November 7, 1888.

16,140. E. Tyer. London. Improvements in the charging of secondary electric batteries from primary batteries, and apparatus for the purpose. November 7, 1888.

16,146. F. Moreton. London. Improvements relating to electro-medical batteries. November 7, 1888.

16,202. J. J. Hine. London. Improvement in and connected with electrical billiard marking apparatus. November 8, 1888.

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COMPLETE SPECIFICATIONS ACCEPTED.

November 10, 1888.

15,217. W. Lowrie, C. J. Hall and H. W. Kolle. London. Improvements in measuring alternating currents of electricity. November 8, 1887.

16,398. B. W. Warwick. London. Automatic machines for the supply of liquids on draught by electrical and other means. November 29, 1887.

16,790. S. C. Hanberg. London. Improvements in dynamo-electric machines. December 6, 1887.

16,807. D. Urquhart. London. Improvements in or connected with incandescent electric lamps. December 6, 1887.

17,582. E. F. H. H. Lauckert. London. Apparatus for indicating the time during which electricity is used for lighting or other purposes. December 21, 1887.

17,641. J. E. Wright and J. Moore. London. Improvements in printing telegraphs. December 22, 1887.

17,807. F. L. Rawson, of and on behalf of the Woodhouse and Rawson Electric Manufacturing Company (Limited). London. Improvements in the construction of rheostats or similar electrical instruments (C. Wirt, New York). December 27, 1887.

203. O. C. D. Ross. London. Improvements in the utilisation of waste products from electrical batteries. January 5, 1888.

295. T. Parker, of the firm of Elwell-Parker (Limited), and E. Rees. Manchester. A new or improved electric meter. January 7, 1888.

1,016. A. M. Taylor. London. An improvement in electrical transforming apparatus. January 23, 1888.

1,105. W. Webster, jun. London. Improvements in the means or appliances for treating sewage by electrolytic action and for disposing of the deposits thereof. January 24, 1888.

2,259. H. Mestern. London. Improvements in thermo-electric and furnace batteries. February 14, 1888.

10,415. C. Gassner, jun. London. Improvements in the manufacture of electrical dry elements. July 18, 1888.

12,066. A. J. Boult. London. Improvements in or relating to electrical type writers capable of being used as printing telegraphs (J. F. McLaughlin, United States). August 21, 1888.

12,754. H. H. Lake. London. Improvements relating to electric bells, and to indicating apparatus for use in connection therewith (W. Humans, United States). September 4, 1888.

13,122. E. J. Paterson and C. F. Cooper. London. Improvements in the armatures of dynamo-electric machines. September 11, 1888.

14,522. D. Humphreys. London. Improvements in galvanic batteries. October 9, 1888.

November 17, 1888.

15,878A. V. Popp. London. New or improved apparatus for measuring the time during which a current of electricity or other fluid is flowing. November 18, 1887. [Note.—This application, having been originally included in No. 15,878, dated November 18, 1887, takes, under Patent Rule 23, that date.]

17,502. G. Hookham. Birmingham. Improvements in electricity meters, parts of which improvements are applicable to dynamo-electric generators and motors. December 20, 1887.

296. T. Parker, of the firm of Elwell-Parker (Limited). Manchester. Improvements in switches for electric circuits. January 7, 1888.

472. W. Webster, Jun. London. Improvements in apparatus for treating sewage and other impure liquids by electrolysis. January 11, 1888.

584. W. L. Madgen. London. Improvements in the method of and apparatus for supplying electric railways or tramways with electricity. January 13, 1888.

1,557. F. Jacob. London. Improvements in duplex telegraphy. February 2, 1888.

4,673A. P. M. Justice. London. Improvements in and relating to switch and cut-out apparatus for incandescent electric lamps (C. Heisler, United States). March 27, 1888. [Note.—This application, having been originally included in No. 4,673, dated March 27, 1888, takes, under Patents Rule 23, that date.]

6,093. F. Jacob. London. Improvements in Morse inker apparatus for telegraphic purposes. April 24, 1888.

12,063. A. J. Boult. London. Improvements in or relating to electrical typewriters capable of being used as printing telegraphs (J. F. McLaughlin, United States). August 21, 1888.

12,064. A. J. Boult. London. Improvements in or relating to electrical typewriters capable of being used as printing telegraphs (J. F. McLaughlin, United States). August 21, 1888.

12,065. A. J. Boult. London. Improvements in or relating to electrical typewriters capable of being used as printing telegraphs (J. F. McLaughlin, United States). August 21, 1888.

12,453. W. P. Thompson. Liverpool. Improvements in apparatus for hardening and tempering by electricity (P. Diehl, United States). August 29, 188 .

14,492. J. B. Sutherland. London. Improvements in electrical signalling, indicating or registering apparatus for railway purposes. October 9, 1888.

14,691. T. N. Vail and J. A. Seely. London. Improvements in telephone central station apparatus. [Date applied for under Section 103 of the Patents, &c., Act, 1883, April 20, 1888.] October 12, 1888.

PATENTS SEALED.

November 9, 1888.

3,533. A. M. Clark. London. Improvements in electric railway signalling apparatus (J. D. Gould, United States). March 8, 1887.

13,960. A. Coleman, Edgbaston, and H. F. Jackson, Sydenham. A novel combination of spring-jack and lightning arrester, for use in or with a test-board, for telephone wires and means of carrying, and a method of arranging any required number of sets or apparatus formed of such combination, such invention being applicable also for the purpose of a telephone switch-board, and for other analogous electrical purposes. October 14, 1887.

14,658. G. E. Fletcher. Stockport. Improvements in electric indicators. October 28, 1887.

6,614. E. G. Craven. London. Improvements in the electrical illumination of clock dials and apparatus in connection therewith. May 3, 1888.

10,691. A. J. Boult. London. Improvements in or relating to electrical transmitting instruments (J. F. McLaughlin, United States). July 24, 1888.

SPECIFICATIONS PUBLISHED DURING THE WEEK.

14,445, 1887. Hadden, R. (Prillwitz). Insulating submarine telegraph cables, &c. (Price 4d.)

14,461, 1887. Stetson, A. Electric accumulators. (Price 8d.)

14,729, 1887. Douglas, W. H. Meter for electrical currents. (Price 11d.)

PATENT

SILICIUM BRONZE AND SILICIUM COPPER WIRE.

The best for overhead Telephone and Telegraph Lines,

AND ALL ELECTRICAL PURPOSES.

Hard Drawn High Conductivity Copper Wire.

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14,834, 1887. LAKE, W. R. (Menges). Regulating steam engines, &c., working electric generators. (Price 8d.)
15,118, 1887. CLARKE, W., and PARSONS, C. A. Electric incandescent lamps. (Price 8d.)
15,922, 1887. COLEMAN, A., and OTHERS. Springjack for telephonic, &c., purposes. (Price 8d.)
16,217, 1887. ALLSOP, F. C. Automatically conveying and delivering letters and small parcels by electricity. (Price 8d.)
16,378, 1887. ALLISON H. J. (The Writing Telegraph Company). Autographic telegraph systems.
16,863, 1887. KING, F. Secondary batteries. (Price 11d.)
12,986, 1888. CRESSWELL, R. Electric sponge. (Price 6d.)
13,192, 1888. ANDREOLI, E. M. H. Bleaching by electrolysis. (Price 6d.)
3,576, 1882. HOPKINSON, J. Distributing, &c., electricity. Second edition (Price 8d.)
16,296, 1887. ST. GEORGE, A. F., and BONNE, C. R. Galvanic batteries. (Price 8d.)
16,603, 1887. BOULT, A. J. (Weber). Electric lamps, &c. (Price 8d.)
17,155, 1887. EDISON, T. A. Incandescent electric lamps, &c. (Price 8d.)
17,508, 1887. RAWSON, F. L., and WHITE, W. Electrical switches. (Price 8d.)
17,523, 1887. ADER, C. Phonic reception of telegraphed communications. (Price 8d.)
17,699, 1887. SMITH, D. J., and SINCLAIR, D. Telephonic apparatus. (Price 8d.)
17,762, 1887. SELLNER, L. Electric signalling apparatus. (Price 11d.)
17,768, 1887. SMITH, W. S. Insulating wire. (Price 6d.)
17,812, 1887. ZIPERNOWSKI, C. Producing alternating electrical currents. (Price 8d.)
39, 1888. TYER, E. Voltaic batteries. (Price 8d.)
804, 1888. PULVERMANN, M. (Bohmeyer). Electric clocks. (Price 8d.)
7,826, 1888. COX, H. B. Galvanic generators. (Price 8d.)
8,170, 1888. ALLISON, H. J. (The Baxter Electric Manufacturing and Motor Co.). Automatically regulated electro motors. (Price 6d.)
10,524, 1888. MILLS, B. J. B. (The Bentley Knight Electric Railway Company). Electric railways. (Price 11d.)
11,092, 1888. CAPELL, G. M., and RAWORTH, J. S. Combined steam engine and dynamo-electric machine. (Price 6d.)
13,008, 1888. OLDROYD, J. W. Electric incandescent lamps. (Price 6d.)
13,126, 1888. CUTTING, W. H. Electric calls. (Price 8d.)
13,825, 1888. LAKE, H. H. (Silliman). Electrical conductors. (Price 6d.)
2,909,* 1877. The Edison Telephone Company's disclaimer and memorandum of alteration—controlling by sound the transmission of electric currents, &c. (Price 8d.)

NEW COMPANIES REGISTERED.

THE DOUGLAS PATENT CLOCK AND ELECTRIC METER COMPANY (LIMITED).—Registered by Waterlow Brothers and Layton (Limited), with a capital of £10,000, in shares of £10 each. Object: to purchase or otherwise acquire and undertake the business of manufacturers of the patent detached pendulum and other clocks, and of meters for the measurement of electric currents, now carried on at 93, Vyse-street, Birmingham, under the firm of the Douglas Patent Clock Company, and to acquire all and every of the assets and liabilities of the said firm in relation to the said business, and with a view thereto to adopt and carry into effect, with or without modification, an agreement dated October 25, 1888, and made between William Henry Douglas, Edwin Lewis Gyde and George William Whitehouse of the one part, and John William Wall, on his own behalf and as trustee for the company, on the other part; to carry on business as manufacturers and factors of the said annual clock and electric meter, and any business of a like or kindred character to that now carried on by the Douglas Patent Clock Company. The first subscribers are:—

	Shares.
W. H. Douglas, High-street, Stourbridge	30
E. L. Gyde, Soho-hill, Handsworth, Birmingham	30
G. W. Whitehouse, Hylton-street, Birmingham	30
T. Parker, Newbridge, Wolverhampton	30
J. Moseley, Cringle Hall, Levenshulme, Manchester	30
H. P. Holt, The Cedars, Dewsbury	30
S. W. Page, The Poplars, Penn Fields, Wolverhampton	1

The first directors shall be Thomas Parker, Edwin Lewis Gyde, George William Whitehouse and William Henry Douglas. The qualification of every director shall be the holding of 30 shares in the capital of the company. The remuneration of directors shall be determined in general meeting. William Henry Douglas shall be the first managing director of the company.

LANCASHIRE ELECTRIC AND ENGINEERING COMPANY (LIMITED).—This company was registered on the 8th inst., with a capital of £20,000, in shares of £5 each, to carry on at Bolton and elsewhere, the businesses of mechanical, hydraulic and general engineers and machine makers, electricians, electrical engineers and workers and dealers in electric and other motive power and light. The first subscribers are:—

	Shares.
*M. Settle, Snow-hill, Darcy Lever, colliery proprietor	1
*J. Atherton, Bolton, mining surveyor	1
*J. Tonge, Westhoughton, mining engineer	1
*G. H. Peace, Tyldesley, mining engineer	1
*G. Crowther, Bolton, mining engineer	1
J. C. Sewell, Bolton, electrical engineer	1
F. W. Briscoe, Bolton, accountant	1

There is not to be less than 5, nor more than 7 directors, and the first are the subscribers denoted by an asterisk; qualification, 10 shares.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 16th, 1888, amounted to £5,456.

EASTERN TELEGRAPH COMPANY.—Sir Albert Cappel, K.C.I.E., late Director-General of Telegraphs in India, has joined the Board of this company.

WEST AFRICAN TELEGRAPH COMPANY.—The offices of this company have been removed from 93, Cannon-street, E.C., to Winchester House, 50, Old Broad-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 16th, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4,495.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended November 15th, 1888, were £2,314, as compared with £2,625 in the corresponding period of 1887, a decrease of £311, July recespts, estimated at £5,331, realised £5,402.

UNITED TELEPHONE COMPANY (LIMITED).—The directors recommend an interim dividend of 5s. per share, being at the rate of 10 per cent. per annum, the same as a year ago.

NOTICES OF REMOVAL.—Messrs. W. T. Goolden and Co. announce that they have removed their offices from 2, Victoria-mansions, Westminster, and their works from Westminster and Halifax, and that in future their only address will be Woodfield-road, Harrow-road, London, W.

——— Messrs. Harvey and Peak have removed from their old address, Beak-street, Regent-street, W., to 6, Sandringham-buildings, Charing Cross-road, London, W.C.

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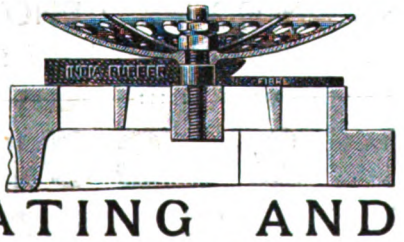

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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Nov. 21, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Nov. 21, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	46 47	2 18 6	Jan., Apr., July, Oct.	47¼	46⅞
2,614,820	Stock	15/0	Do. Preferred	77 78	3 10 6	,, ,,	78⅜	77¼
2,614,820	Stock	nil.	Do. Deferred	15½ 16	...	February	15½	15⅛
130,000	£10	5/0	Brazilian Submarine xd and bonus	13⅛ 13⅜	5 5 5	Mar., June, Oct., Dec.	13⅜	13⅛
16,000	10	9/0	Cuba Submarine	13¾ 14¼	5 19 9	February and August	14⅛	14
6,000	10	10/0	Do. Preference	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4½	3 11 1	March & September	4⅛	...
6,000	5	10/0	Do. Preference	9 10	5 0 0	April and October	10	...
60,710	20	2/0	Direct United States	9⅝ 9¾	4 1 0	Jan., Apr., July, Oct.	10	9⅞
380,000	10	4/6	Eastern	12⅜ 12⅝	4 15 1	,, ,,	12½	12⅜
70,000	10	3/0	Do. 6 per Cent. Preference	14⅜ 15¼	3 19 0	,, ,,	14¾	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	3 18 0	February & August	...	...
250,000	10	2/6	Eastern Extension	13⅛ 13⅜	4 17 2	Jan., Apr., July, Oct.	13⅜	13⅛
22,050	10	8/3	German Union Telegraph and Trust	9 9½	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅞ 7⅛	4 18 3	Jan., Apr., July, Oct.	7⅛	6⅞
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14⅝	14⅜
150,000	10	5/0	Great Northern	14¼ 14⅜	5 1 8	Jan., July, and April	14⅜	14⅜
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
33,348	10	3/0	London Platino Brazilian xd	7½ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7½	5 12 0	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98½	98⅛
30,000	10	6/0	West Coast of America	9¼ 9⅜	5 2 7	January and July	9½	9¼
150,000	100	8%	Do. Debentures	121 125	6 8 0	June and December	...	...
88,321	10	1% '78	West India and Panama	1⅞ 2⅛	...	...	2	1⅞
34,563	10	12/0	Do. 1st Preference	12¼ 12⅜	8 12 6	April and October	12⅜	12⅝
4,669	10	*	Do. 5 per Cent. 2nd Preference	12 13	...	...	12⅜	12¼
45,181	15	6/0	Western Brazilian	13⅜ 14¼	5 7 6	March & September	14⅛	14
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	1⅛ 1⅛	5 10 0	Yearly	...	...
220,000	£1	2½%'87	Oriental (11s. paid)	⅜ ⅝	2 14 11	...	...	...
80,000	5	10/0	United	13⅞ 14¼	5 5 3	June and December	14¼	14
55,000	5	4/6	United River Plate	5½ 5¾	...	January and July	5⅞	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3¾ 4¼	...	...	4⅛	4
23,692	5	nil.	Do. (fully paid)	4⅝ 5¼	...	February & August	5⅛	5
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	...	...
312,000	¼	5% '86	Maxim-Weston	1⅛ 1⅜	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	39 40	6 0 1	March and July	39⅞	39¼
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	16½ 17½	5 14 3	February & August	17¼	17⅛

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 550.—Vol. XXII. FRIDAY, NOVEMBER 30, 1888. Price 4d.

NOTES.

We publish this week, from the pen of Mr. Preece, a most interesting Paper, written thirty-four years ago, containing an account of some experiments on the retardation of signals on underground telegraph circuits, in which Faraday, Latimer Clark and Sir George Airy were engaged.

We have received from the Chelsea Electric Supply Company a copy of a memorial which has been addressed by them to the Chelsea Vestry with regard to an application on the part of the London Electric Supply Corporation for permission to carry an underground main through the centre of the Chelsea district. It will be recollected that the first-named company is in possession of an Act of Parliament confirming a Provisional Order for lighting this district; they have already deposited with the Board of Trade the required guarantee (£2,000), and are now at work upon the mains. Under these circumstances the protest contained in the memorial is a not unreasonable one, and it is certainly of equal importance to all parties concerned that the precise degree of monopoly conferred by a Provisional Order should be speedily made known. It is desirable, also, that the extent of the powers vested in the Board of Trade, and the precise line of demarcation between its jurisdiction and that of the local authority, should be more clearly defined. We have already pointed out that, as a matter of fact, the powers of the Board of Trade are very nearly absolute when once a company has come within its cognisance either by License or by Provisional Order, and the present case appears to afford a good opportunity for ascertaining the scope of their authority over other works within a scheduled district. We may add that we have reason to believe that the Board may before long be expected to make some pronouncement in the matter of overhead wires.

It will be generally admitted that the perfection of alternate-current motors is at the present time the most pressing and the most important problem with which the attention of electrical engineers is occupied. The Tesla motor, in the hands of the Westinghouse Company, even if it does not at this moment present a final solution of the problem, does certainly possess so many and such striking advantages that we may be quite certain that no effort will be spared to bring it to perfection. At present, however, we believe that the difficulty of making it self-starting, which was referred to at some length by Mr. W. J. Swinburne, in *The Electrician* of July 20th, 1888, has not been altogether overcome. There is also the disadvantage of the double main. In the Westinghouse system, however, it happens that this is of comparatively small importance—and for this reason, the Westinghouse Company, working at only 1,000 volts in the primary, prefers to restrict its circuits to a maximum load of about 1,500 lamps. Hence it will be comparatively easy to arrange to bring two separate circuits run from separate machines at the necessary quarter-phase interval into any given locality. The motor can then be run off two distinct lighting circuits without additional expense in leads.

On the question of working motors of this type from a single pair of mains we may recommend those interested to re-read the Paper of Prof. Galileo Ferraris, an abstract of which appeared in *The Electrician* of May 25, 1888, a date antecedent, by-the-bye, to the publication in this country of Mr. Tesla's independent work in the same direction. Prof. Ferraris proposed to overcome the difficulty by exciting the field of the motor by means of a transformer wound with one primary and two secondary coils. In one secondary circuit he would place as much inductance and as little resistance as possible, and in the other he would have little inductance and as great a resistance as might be necessary. In this way the phase of the two secondary currents would be displaced by an amount tending in the limit to 90 degrees. The method must be to some extent wasteful of energy, but we may suggest that in practice it might prove sufficient to connect one set of field coils in parallel and the other set in series. Those coils which are to be connected in series would have to be of large wire, so as to reduce the resistance as much as possible, and those which are in parallel would either be of finer wire or else a non-inductive resistance would be inserted. Since we should be working from a transformer it would be easy enough to adjust the voltages, but whether it would be possible to carry this principle far enough to obtain a displacement of phase sufficient for economical working is a question upon which we hazard no opinion at present. There are doubtless other ways of obtaining the same end—such as the use of impedance coils—but we strongly suspect that all the more obvious of these devices have already been tried at Pittsburg, and have been found wanting.

At the meeting of the Society of Telegraph Engineers last week, Mr. Edmunds' Paper "On a New System of Electrical Distribution" did not lead to any very lively discussion. The

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compliments which were paid to the ingenuity of the inventor were doubtless both sincerely meant and thoroughly well deserved; but nevertheless there was an unmistakable feeling that as yet the time had hardly arrived for a recognition of the system as a practicable and commercial method of distribution. In fact, the almost total absence of figures, especially as to the first cost of the "distributor"—one of which, it must be remembered, Mr. EDMUNDS proposes to place in every house—could not fail to give an air of unreality to the whole thing. Opinions were freely expressed at the close of the meeting that the apparatus could not be made for less than £50 or £60 apiece; and if this be anywhere near the mark, it seems scarcely worth while to discuss the chances of its satisfactory working, or the advantages of the intermittent method of charging accumulators. It must also be noted that the first cost of the batteries is increased by 33 per cent. over the ordinary B.T. system. If Mr. EDMUNDS' system should really prove its ability to rise superior to such considerations as these, then it will be difficult to award him too high praise; but at the present moment we must be pardoned if we regard the system rather as a brilliant *tour de force* than as a substantial addition to the resources of electrical engineering.

ONE of the most interesting of the many interesting features which this *tour de force* presents is the method of maintaining the current constant by the simple provision of a constant magnetic field in the dynamo with constant steam pressure in the cylinders, and a consequent automatic variation of the speed of the engine. Mr. KAPP takes exception to this method on the ground of the want of economy in coal when the engine is running at its slowest. At the Cadogan Central Lighting Station (which was described in *The Electrician* of July 20th, 1888) this objection is to a great extent overcome by the employment of three engines and dynamos, which are run in series for the full load, so that only one-third of the steam plant is ever worked under uneconomical conditions. Mr. KAPP, and some of the other speakers as well, were apparently under some misapprehension as to the way in which the batteries are actually used—a misapprehension which led them to question Mr. EDMUNDS' claim that the generating plant need be only equivalent to one-third of the total output. The mere fact that Mr. EDMUNDS proposes to run his engine 24 hours per diem shows that it is incorrect to suppose that the batteries "are not allowed to accumulate a charge." On the contrary, the idea is that at the commencement of the hours of lighting the whole of the batteries are more or less fully charged. And since they are on the charging circuit for only two minutes to every six minutes of discharge, the tendency during the period of full load is to run them down. The "hand-to-mouth" principle to which some of the speakers referred is not a feature of the system, and would not under the circumstances be practicable, unless indeed the cells received their charge at three times the rate of discharge.

ONE other feature of the Edmunds system, to which we are rather surprised that no reference was made either in the Paper or in the discussion, is the fact that in order to utilise the current of 70 amperes on the charging circuit throughout the whole installation the cells must all have the same capacity. In the smaller installations, therefore, the number of cells is diminished, and lamps of lower voltage are made use of. This arrangement tends to relatively diminish the cost of small installations, but the multiplication of lamp voltages is not advantageous.

POSSIBLY the most valuable—and, at any rate, the most novel—contribution to the general stock of knowledge which was elicited during the discussion is contained in a remark by Mr. W. H. PREECE. Referring to the fact that a battery discharges itself at a lower voltage than that at which it is charged, Mr. PREECE said, truly enough, that "the general impression of the great majority of men in that room was that under these circumstances they got a great loss of energy." We confess that we have hitherto shared this impression. It appears, however, that this is not so; although we are afraid that we do not as yet clearly comprehend how it comes to be otherwise. Everyone is of course familiar with the fact that the resistance of a cell decreases as the *charge* is increased, so that a well-conditioned cell has an internal resistance about one-half as great when fully charged as when nearly discharged. But Mr. PREECE has recently discovered that during the discharge the internal resistance varies approximately inversely as the current. If so, it might be supposed that we should get a higher efficiency the more rapidly the discharge takes place. Yet Mr. PREECE, in recounting an instance of a 98 per cent. efficiency, says that this was obtained with a discharge of only one ampere. Possibly the present confusion of our ideas upon the subject is sufficiently accounted for by the bare mention of a 98 per cent. efficiency, and when we have become somewhat more accustomed to this degree of magnificence we shall be better able to understand the argument. Meanwhile we feel decidedly fogged.

THE Paper read by Prof. RÜCKER at the last meeting of the Physical Society, and of which an abstract will be found in another column, forms a most important contribution to the difficult subject of physical units, and we cordially re-echo the hope expressed by Prof. CAREY FOSTER at the meeting, that the Paper may be adequately discussed when it has been printed *in extenso*. There are few students to be found whose minds are not in a hopeless fog on the subject of the dimensions of electrical and magnetic units expressed in the two systems in practical use, and, as Prof. AYRTON pointed out during the discussion, there is evidence that this fog has not been entirely dissipated from the minds of many of those to whom students turn for instruction. Prof. RÜCKER's suggestions appear to provide an efficient means for clearing the mental atmosphere in this respect, and, as such, we would commend them to the careful attention of students and physicists alike.

WE are pleased—though not surprised—to find that the views which we expressed last week as to the coupling of cells for electric traction are fully shared by no less an authority than Mr. A. RECKENZAUN. We understand that in his designs for electric tramcars Mr. RECKENZAUN never allows the cells

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to be placed in parallel. It would be interesting to learn exactly how many accumulator cells were knocked up from this cause in the electric launches which appeared last year on the Thames. It is satisfactory to know that the experience gained has not been of so unfavourable a character as to damp the ardour of those engaged in the enterprise, for at the present time we know of nearly a dozen launches which are under construction. And if the practice of coupling cells in parallel is abandoned we are satisfied that results of a far more encouraging character will next season be obtained.

ONCE more we enter upon a period of electrical litigation. The case of King, Brown and Co. *v.* The Anglo-American Brush Corporation, in which the pursuers seek to annul the compound-winding patent now held by the defenders, came before the Edinburgh Court of Session on Tuesday last, and is being specially reported for *The Electrician*. It may be as well to note that the Mr. HADDAN whose name is prominent in the proceedings is the "Cheesebrough" of compound-winding; that is to say HADDAN is the name of the Patent Agent who received "a communication from abroad" containing the patent specification now in dispute. Edison and Swan *v.* Holland and Others comes before the Court of Appeal within the next few days, and will be immediately followed in the same Court by Ferranti *v.* Gaulard-Gibbs.

THE promoters of the Mining and General Electric Light Company, the prospectus of which has been issued this week, estimate that if the sale of their portable storage battery lamp reaches "only 80,000" per annum, a profit of 15 per cent. on a capital of £100,000 will be forthcoming. This is a proposition which we need not dispute. Nevertheless, we do not believe that it can be held to justify the payment of such an exorbitant sum as £80,000 (£46,000 in cash) for the patent rights. The lamp is said to weigh 5lb., for about six hours' burning, and to cost £1. But we fail to understand what security exists that the invention (if invention it be) approximates near enough to perfection to justify a price which would be reasonable only in the case of an entire monopoly of the business.

WE learn from the Moscow *Technik* that M. BEKETOV, of Charkoff, has succeeded in the economical production of metallic sodium by the electrolysis of the fused chloride (common salt). If the process should prove to give satisfactory results on a large scale of working it may very probably have a future of some importance in connection with the St. Clair Deville process for the manufacture of aluminium, in which the preparation of metallic sodium is at present one of the most costly stages. At the fusing temperature of sodium chloride (500° C.) it possesses considerable conductivity. The electrolysis is effected in a cylinder of earthenware. The electrodes are introduced at either end, passing through porcelain tubes which extend beyond the poles on the inner side. The positive electrode is of carbon, and the negative of iron. The latter is pierced longitudinally by a canal, through which the metallic sodium continually runs away. The method of carrying off the chlorine is not described, but probably it presents no difficulty. The fused salt is introduced from time to time by an opening at the centre of the chamber. With a current of 16,000 amperes under an E.M.F. of 5 volts (or about 120 horse-power) 50 pouds (or about 1,800lb.) of salt can be decomposed in twenty-four hours, yielding 720lb. of the metal and 1,080lb. of chlorine. Assuming that about five tons of coal are consumed, it will be evident that at the present value of sodium, to say nothing of the chlorine, the process ought to yield a very handsome profit.

THE *United Service Gazette* is responsible for the following:—"The dockyard authorities have been asked to report on the advisability of lighting the dockyards throughout by electricity, using Ferranti's system of a central station and transformers. At Portsmouth it was suggested that the central pumping station might be utilised to generate the electricity. But there is yet comfort for the Portsmouth Gas Company. The dockyard officers reported they did not consider that Ferranti's system was sufficiently perfected at present, and that when the pumping station was pumping out a dock, there would not be sufficient power to spare for lighting purposes."

A New Technical Journal.—We understand that a new fortnightly electrical journal will appear, at the beginning of the new year, under the title of "THE TELEPHONE."

The Elmore Process.—We understand that Messrs. Woodhouse and Rawson have taken up the Elmore process of manufacturing copper wire, and will shortly be prepared to supply wire of this description.

Cable Ships and Cricket.—A cricket match was played recently at Cape Town between the combined teams of the cable ships "Great Northern" and "Amber" and the Garrison team, which resulted in an easy victory for the latter. The scores are not to hand.

Oldham.—Messrs. John Barker and Sons (Limited), engineers, Oldham, have decided to light their new foundry works by electricity. The Lever system has been selected, and the order has been placed in the hands of Mr. Charles Lever, of Bowdon, Cheshire.

Morecambe.—At the last meeting of the Local Board a notice was read from Messrs. Andrews and Preece, dated 29th October, 1888, stating their intention to apply for a provisional order authorising the supply of electricity within the district. It was resolved unanimously that the question of lighting the district by electricity be recommended to the Board for consideration.

The British Electric Light Company.—The scheme of arrangement for resuscitating the British Electric Light Company has been sanctioned by the Court, and a circular is now being issued requesting the creditors of the company to send in particulars of their claims in order that preference shares may be issued to them in accordance with the terms of the scheme.

A Submarine Cable Concession.—The Dutch authorities have granted a sixty years' concession to the Pedro Segundo Cable Company to lay and work submarine cables between Willemstad (Curaçoa), Paramito (Surinam) and Vizen (Brazil). The cables are to be laid within eighteen months, and an annual subsidy of 20,000 florins will be paid to the company for the first twenty years.

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Buckingham Palace.—We understand that the hall at Buckingham Palace is to be fitted with the electric light before next season, but the Queen will not allow the light to be introduced into the private apartments at Windsor Castle, as her Majesty prefers shaded lamps and wax candles. The State apartments, the hall, and the lower end of the corridor are fitted with electric light, but it is to go no further at present.

St. James's Vestry.—A special meeting of the St. James's Vestry was held on Thursday morning, Mr. John Bonthron presiding, at which it was decided, at the instance of Mr. William Jenkins, to consent to the application by the Metropolitan Electric Supply Company (Limited), to the Board of Trade for a provisional order to supply electricity in the parish. An application by the House to House Electric Supply Company was referred to committee.

Newington Vestry.—At a meeting of the Newington Vestry on Wednesday evening, the Rector (the Rev. G. T. Palmer, M.A.,) presiding, an application was made by the House to House Electric Light Supply Company for permission to apply to the Board of Trade for a provisional order to light the district. Consent, it may be mentioned, has already been given for the application for provisional orders by three other companies. The letter was referred to the General Purposes Committee.

The Electric Light at the Glasgow Post Office.—About eight o'clock on Monday night last, according to the *Standard*, the *employés* in the Glasgow Post Office were surprised to find all the electric lights suddenly go out. It was next reported that a fire was seen on the roof. The clerks ran out the hose, and were doing their best to extinguish the flames when the brigade arrived, and in a few minutes the outbreak was got under. The fire was caused, it is said, by some defect in connection with the electric lighting apparatus.

The House-to-House Electric Lighting Company at Brompton.—It is announced that the Central Lighting Station of this company at Brompton (on the Lowrie-Hall system) is expected to be ready for work by the middle of December. The following tariff has been fixed:—At the rate of 1s. per Board of Trade unit for the first 100 hours; 8d. per Board of Trade unit for the second 100 hours; 4d. per Board of Trade unit for any further quantity consumed. Rent of meter, instruments, &c., 5s. per Board of Trade unit per quarter.

E.P.S Smoking Concert.—The Electrical Power Storage Company held, what we understand is the first, of a series of smoking concerts in connection with their cricket club, on Monday evening, at the Eastern Hotel, Limehouse, near their works. In the unavoidable absence of Sir Daniel Cooper, the chair was taken by Mr. John Irving Courtenay, the managing director of the company. The programme was of a varied and attractive character, and was rendered in a highly successful manner. Many of the friends of the E.P.S. Company as well as the *employés* were present.

St. Martin-in-the-Field Vestry.—At the last meeting of this Vestry a letter was read from the London Electric Supply Corporation, requesting permission to lay an underground main in Durham-street from the Adelphi-arches, across the Strand to the passage leading to the premises of the Corps of Commissionaires, and enclosing draft of an agreement for that purpose; and the Clerk having reported that the agreement had been so drafted as sufficiently to protect the interests of the Vestry, the committee recommended that the draft be approved, and an agreement be entered into with the Corporation in accordance therewith. This was agreed to.

Wood Casing for Electric Wires.—Messrs. J. F. and G. Harris (of 56 and 60, Wilson-street, Finsbury) send for our inspection some very excellent white wood moulding, designed especially for casing electric light wires of various sizes. This firm are large dealers in wood and timber, and they pay special attention to machine mouldings of every description. Having a large connection amongst builders and wholesale shippers, Messrs. Harris possess every facility for turning out large quantities of material at short notice, and they should also be able to compete successfully with their rivals in the matter of price. The mouldings sent to us are of handsome appearance, and, being finished with a beading on the inner edge of the cone, the joints are invisible.

The Anglo-American Brush Electric Light Corporation (Limited) have just booked an important order from the Pacific Steamship Company for several of their plants of combined engines and dynamos, specially designed for use on board ship. We hear that the company is also exceedingly busy with general orders, and its prospects seem very encouraging. The important contract which it entered into some time since for the lighting of the Glasgow Exhibition has just been completed, to the entire satisfaction of the executive committee of the exhibition. As we also note elsewhere, the Brush Corporation have been awarded a gold medal for their electric fountain display at the Barcelona Exhibition, and a diploma of honour for electric lighting at Brussels.

A Crew Disabled by Lightning.—The Guion Line steamer "Alaska," from New York, brings intelligence of the ship "Edward," from Havre, with a cargo of iron ore, whose captain reported that the vessel encountered a terrible storm in the Atlantic on the night of the 31st ult. The vessel was continuously enveloped in lightning, which prostrated on the deck eleven seamen, and deprived them of sight for nearly half a day. The second officer and the boatswain were also dashed to the deck, and received serious injury. Three balls of fire exploded with a tremendous report over the main rigging, scattering flaming fragments over the ship, and driving the remaining members of the crew in terror into the forecastle. From 3 a.m. until 7 p.m. the captain and mate were the only persons on board capable of doing any work.

St. Margaret's and St. John's Vestry.—At a meeting of the St. Margaret's and St. John's Vestry (Westminster), on Wednesday afternoon, Mr. H. Bowman Spink presiding, the Parliamentary Committee reported that they had considered the reference on the question of the desirability of the Vestry applying for a licence or provisional order for the lighting of the parish by electricity; but, having regard to circumstances generally, they did not think it would be expedient for the Vestry to do so at the present time. The following resolution was eventually agreed to: "That the recommendation now submitted be referred back to the Parliamentary Committee, with power to fully inquire into the whole question of electric lighting, and with authority to inquire of the lighting corporations of London and the provinces, the committee to have leave also to inspect the works of any of the companies in or near London formed for the purpose of supplying the light."

Opening of the Derby Telephone Exchange.—The National Telephone Company opened a Telephone Exchange in Derby on Monday afternoon last. The Exchange opens with a membership of about 20. When the company's line from Birmingham to London is completed, Derby will be placed in direct communication with the metropolis. Through communication with the great Yorkshire towns will also be made in a few weeks. The formal ceremony of opening the Exchange was performed at the Lecture Hall, in the Wardwick, where a large number of persons assembled. Ald. Roe, M.P., proceeded to formally declare the Exchange open, adding that he wished it

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every success. The gentlemen present then adjourned to the ante rooms, into which several wires connecting with the trunk lines had been introduced. They there heard musical performances in Birmingham, Sheffield, and Nottingham, and many of the party afterwards visited the head-quarters of the Exchange in Becket Well-lane.

Electricity and Underground Haulage.—At a meeting of Mining Engineers in South Wales, held last week, Mr. J. Fox Tallis read a Paper on "The Application of Electricity to Underground Haulage." It was patent, the writer observed, that the old servants, steam, air, and water, were limited in their scope of adapting themselves to existing and future circumstances. Colliery proprietors would be the first to admit the inadequacy of present systems to meet the requirements of to-day, and would be the first to appreciate and adopt an improved system that offered greater facilities of transmission over longer districts and more extended areas. Electricity, he contended, had the advantages of being more easily and economically subdivided into a number of paths, fewer moving parts, small and fixed mains, less liability to injury, less space, and greater efficiency. The Paper did not go into the subject of locomotive motors, as the writer did not consider them practicable, but claimed that the electric motor was the best means for underground hauling. The Paper was ordered to be printed for discussion at the next meeting.

Electric Light in the Dockyards.—Although the electric light has not superseded gas in the Dockyards, says the *United Service Gazette*, it has been extremely useful as an additional illuminant where gas could not conveniently or safely be used. The old custom, when men were working under ships' bottoms in dock, was to have what were well called "stink pots"—that is, iron pots containing tallow and oakum, which took two men to look after them, and made more smoke than light. Then innumerable candles were used in the double bottoms and other interior portions of ships building. It will easily be understood that these did little more than make darkness visible, so that the inspection of work before the advent of electricity was a very tedious business. Now, each ship of any size, as soon as it is launched, has an electric light engine placed on the upper deck, and strings of incandescent lights are placed in any part of the ship where work is going on. Before she is launched, as soon as the light is required, it is provided from an engine which supplies one or two ships, according to size. By this means work is done much better than it would be if completed in semi-darkness, and efficient supervision can be constantly exercised.

Formation of an "Electrical Institute of New South Wales."—We have received the following very interesting communication by the last mail from Australia:—"Sir: It may perhaps interest you to hear of the formation of this institute, which has now been in existence some three months. The project was started by five of us, and at the time of writing we have fifty-four members. We have been able to secure rooms in a central part of the city, which are open daily from 10 a.m. to 11 p.m., and supplied with various papers, including *The Electrician*, *Electrical Review*, *Engineering*, *Engineer*, *Nature*, *Building and Engineering Journal of New South Wales*, &c. The last-named paper has offered to print all our Papers and discussions for us free. So far five Papers have been read at the fortnightly meetings, which have provoked much interesting discussion. I enclose a copy of our rules, containing also a list of members up to the date of printing. It is to be hoped that the institute will fulfil its object in promoting good feeling between the members of our profession out here, for up till now there has been a great want of that friendly intercourse so pleasant at home.—Yours, &c., E. R. Dymond, Stud. Inst. C.E., Acting Sec."

The Areas of Electric Lighting.—The following letter appeared in the last number of the *Municipal Review*:—"Sir: A typical debate on the above subject, on which a few words may not be out of place, took place at the Kensington Vestry on the 14th inst. The point on which the discussion hinged is sure to arise in other districts. It is therefore one of more than local interest. A committee of the Vestry excluded from consideration the application of a most solvent and influential electric lighting company for permission to apply to Parliament for a provisional order to light a portion of the parish of Kensington. The exclusion was based avowedly on the ground that, inasmuch as the works of the company were situated in another parish, it would be inexpedient to permit the company to light Kensington. For, it was argued by the committee, if at any time hereafter Kensington should decide to supply itself with electric light, the fact that the works of the company owning the Kensington wires were not situated in Kensington would be an insuperable bar to the scheme. For how, it was urged, could the wires be bought without the works from which they were fed, and how could one parish buy property situated in another, over which the first parish had no control? I venture to say, sir, that I can supply two answers, either of which, as I submit, disposes of the committee's argument. First, Kensington can, and does, own property in other parishes. For instance, a wharf in Hammersmith and a dust-shoot at Purfleet. Secondly, the Committee's objection only proves the inadvisability of mere parishes or districts, which are but fragments of London, owning such properties at all. The new County Council clearly is not open to the same objection.—I am, sir, yours, &c., James F. Torr."

The Lighting of Cowpen.—At a meeting of the Cowpen Local Board, held at the beginning of the month, a deputation from the Blyth Gas Company explained to the Board the lowest terms at which the gas company could afford to light the district. A representative of Messrs. Nicholson and Jennings, of London, then had an interview with the Board. He said they were prepared to light the town for £600 a year; he gave it as his opinion that eighteen electric lamps would suffice. The shortest period for which his company would tender was seven years. An adjourned meeting of the Local Board was held on the 13th inst. to consider the matters referred to above. After some discussion it was proposed that a committee be appointed to confer with the electric light company to see whether a shorter term than seven years could not be arranged for a contract. The words, "and with the gas and oil companies," having been inserted, the motion was carried. At a special meeting of the Local Board on Wednesday, 21st, the public lighting question was again under consideration. The chairman reported that the committee appointed at the last meeting of the Board had fully considered the subject of public lighting, and had come to the conclusion to recommend the Board to make an offer to Messrs. Nicholson and Jennings. They were to be asked to supply electricity at the rate of £550 per lighting season for 18 arc lamps of 2,000 candle-power, for a period of five years, subject to conditions and arrangements to be mutually agreed upon; the work to be satisfactorily completed within a period of two months from the date of signing the contract.—Mr. Whiteman proposed that the words, "Further, that all arrangements and sanctions necessary from the Board of Trade be obtained by contractors," be added to the recommendation of the committee. This proposal having been agreed to, the committee's recommendation was unanimously adopted.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 41.)

Returning to the equations (5) and (6) we can now find the constants of integration, counting the time from the instant of "make" of the primary. It is obvious that when $t = 0$, $y = 0$ and $x = 0$, and that the whole quantity of the make-induced current, or $\int_0^\infty y\,dt$, must be equal to the whole quantity of the break-induced current, which we have seen is equal to $\frac{M\,I}{R}$.

In (6) put $t = 0$, $y = 0$; we get

$$A' + B' = 0, \qquad \text{or } B' = -A'.$$

Hence,
$$y = A\left(e^{-\frac{Rt}{L+M}} - e^{-\frac{Rt}{L-M}}\right)$$

and
$$\int_0^\infty y\,dt = -\frac{2A'M}{R}.$$

Hence the whole quantity of the "make"-induced current is $-\frac{2A'M}{R}$, and this must be equal to $\frac{MI}{R}$, which is the whole quantity of the "break" current. Hence $A' = -\frac{I}{2}$.

Therefore we get for the instantaneous strength of the "make" secondary current

$$y = -\frac{I}{2}\left(e^{-\frac{Rt}{L+M}} - e^{-\frac{Rt}{L-M}}\right) \quad . \quad . \quad . \quad (8)$$

Again in (5) put $t = 0$, $x = 0$,

and we get $A + B + I = 0$,

or $B = -(I + A)$;

and by substitution in (5)

$$x = A\,e^{-\frac{Rt}{L+M}} - (A + I)\,e^{-\frac{R}{L-M}} + I.$$

From this equation we can find the value of A by substituting the value of $\frac{dy}{dt}$ derived from equation (8), and $\frac{dx}{dt}$ derived from the above in the original differential equation (i.), and we find $A = -\frac{I}{2}$. Hence we arrive at the equation for the value of the primary current at any instant, and it is

$$x = I - \frac{I}{2}\left(e^{-\frac{Rt}{L+M}} + e^{-\frac{Rt}{L-M}}\right) \quad . \quad . \quad . \quad (9)$$

This gives the law according to which the primary current grows up in its circuit if $M = 0$; that is, if there is no secondary circuit; then

$$x = I\left(1 - e^{-\frac{Rt}{L}}\right)$$

which is the ordinary law of current growth. If $M = L$, which is the greatest possible value of M, then

$$x = I\left(1 - \frac{1}{2}\,e^{-\frac{Rt}{2L}}\right).$$

Hence it is obvious that the presence of the secondary circuit hastens the rise of the primary current and operates on it to reduce its inductance.

On making the primary we get a "make" or inverse secondary current according to the law of growth expressed by the equation

$$y = -\frac{I}{2}\left(e^{-\frac{Rt}{L+M}} - e^{-\frac{Rt}{L-M}}\right),$$

and we see that under the circumstances assumed the "make" secondary starts from an initial value zero, rises up to a maximum, and then decays away again. To find the time of reaching maximum, equate $\frac{dy}{dt}$ to zero, and we find

$$t' = \frac{L^2 - M^2}{2\,R\,M}\log\left(\frac{L+M}{L-M}\right),$$

and this function *increases* as M *decreases*. So that the more nearly M is equal to L the *sooner* does the secondary reach its maximum. It is not difficult to show that when $M = L$ the above value for t' becomes zero, and when $M = 0$ $t' = \frac{L}{R}$.

If, then, we trace a series of curves (Fig. 11) representing the values of y, or the make-induced current at each instant for various and increasing values of $\frac{L}{M}$ as the coils are moved further apart, we find a series of curves with decreasing maxima, but the maxima happening later as M decreases.

Lastly, on breaking the primary current we have a break-induced current in the same direction as the primary, which, at any instant after the "break," is decaying away according to the law

$$z = \frac{M}{L}\,I\,e^{-\frac{Rt}{L}}.$$

If the break was absolutely instantaneous, the induced current would start with a finite value equal to $\frac{M}{L}$ of that of the primary, but as no form of break entirely eliminates sparking, the rise of the direct secondary current is a gradual one. Also we have another element of disturbance which enters into the case. The self-induction of the primary creates direct electromotive force in its own circuit at the instant when the induction through the primary due to its own current vanishes. When

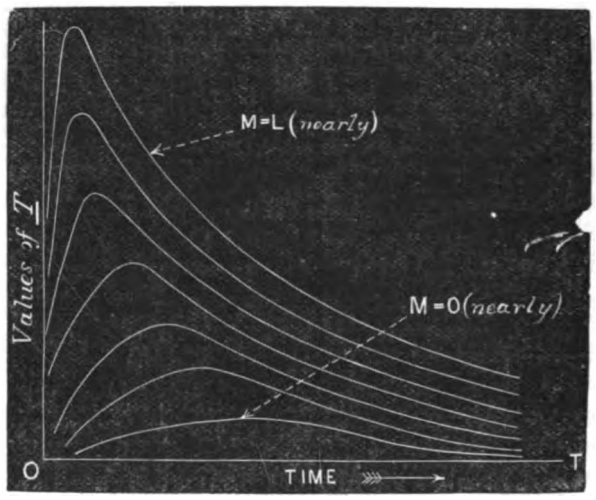

FIG. 11.

Curves representing roughly the current value of the make-induced current for different and increasing values of M.

the primary is broken either at a mercury cup or at a platinum point the fusion and volatilisation of metal which takes place keeps open for a little time a conductive path through which flows the *extra current* due to the self-induction of the primary. This extra current may have at a particular instant a higher value than that of the strength of the steady current, so that for a short instant the primary current may be actually increased on beginning to break the circuit before it commences to decay.

This direct extra current in the primary will have its effect in introducing a very short inverse-induced current, which will precede the main direct-induced current due to the decay of the primary current. In any event it will introduce an electrical oscillation tending to render the growth of the direct secondary current a gradual matter. It is an interesting case to examine the relative maximum values and duration of the two induced currents under an assumption very nearly realised when the primary and secondary are wound together on the same bobbin, viz., when $M = L$. In this case the values of y and z become

$$y = \frac{I}{2}\,e^{-\frac{Rt}{2L}}$$

$$z = I\,e^{-\frac{R}{L}}.$$

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The maximum of the direct currents ("break") is I, and that of the inverse (or "make") is $\frac{I}{2}$. If we wish to know at the end of what times t and t' the strengths of the two induced currents y and z are reduced to $\frac{1}{m}$ of that of the primary we obtain by substitution of $\frac{1}{m}$ for y and z in the two above equations the following :—

$$\frac{1}{m} = e^{-\frac{Rt}{L}}$$ for the direct-induced current,

and $$\frac{1}{m} = \frac{1}{2} e^{-\frac{Rt'}{2L}}$$ for the inverse-induced current,

and therefore $$\frac{t'}{t} = 2\left(1 - \frac{\log 2}{\log m}\right).$$

We see that t' is always greater than t, and that in proportion as m increases, t' tends towards a limit $2t$, or the inverse current has a duration about double that of the direct secondary. We shall now see how this theory is confirmed by experiment.

(To be continued.)

SELF-INDUCTION AND RETARDATION.

BY W. H. PREECE, F.R.S.

Experiments made at the Strand Office of the Electric Telegraph Co., May 21, 1854.

Length of wire 1,100 *miles (underground.)**

Experiment I.—A repetition of an experiment at Lothbury, showing the jerk or extra deflection of the needle at the moment of interruption, and the reversal of its poles in consequence. This Prof. Faraday attributed to the induction of a current upon itself, but Mr. Latimer Clark considered it to be due to the intense and sudden action of the return current. Power used 560 cells. [Sand battery, viz., zinc-copper H_2SO_4.] (1) Upon charging the wire the needle deflected to A, as shown in Fig. 1; upon discharging it gave a further

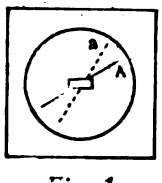

Fig. 1.

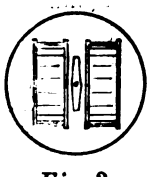

Fig. 2.

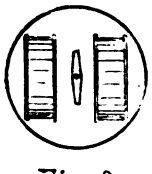

Fig. 3.

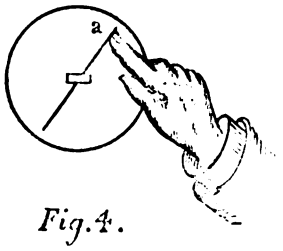

Fig. 4.

jerk to the right and fell back to the vertical, the poles having become completely reversed, for on recharging the wire the needle deflected to the opposite side. This could be repeated at pleasure to the left and right.

(2) Upon increasing the distance of the coils from the needle (*vide* Figs. 2 and 3) and from each other, so as to lessen the power of the current upon the needle and bring it to the dotted position (a), Fig. 1, no such effect occurred. There was no extra deflection and the discharge deflected the needle in the usual direction, viz., contrary to that of the primary current.

(3) Upon examining the needle, taken out while under the influence of the primary current, the coils being closed, and also after the discharge, the polarity in each case was found different.

(4) Upon moving up the needle to the position (a), while under the action of the primary current, and then discharging the wire, no jerk could be perceived upon the finger, and the discharge deflected the needle in the usual direction.

(5) The reversal of the poles and the jerk could only be produced when the needle was deflected above 60 degrees.

These experiments prove beyond doubt that this extra deflection, and consequent reversal of the poles of the needle, is due to the intense and sudden action of the discharge or return current, and not to any extra current induced in the wire by the primary current itself; indeed, in all our experiments upon long wires we can never trace any effects resulting from the induction of a current upon itself.

Experiment II. (Prof. Airy's).—The wires were arranged thus :—

Galvanometers placed at A the "near" end, at B 374 miles off, and at C, the further end, 1,100 miles off. Upon using the intensity of 560 cells, and then of 200 cells, no perceptible difference could be observed in the transmission of the current from the two batteries. It took about eight-tenths of a second after contact was made before any movement could be perceived in needle C. The deflection commenced with a gentle movement, increasing rapidly as the deflection increased (perhaps a little more rapidly with the more intense current, but scarcely perceptible to the eye). The period which each current took to deflect the needle was apparently equal, but the needle fell back in the first case when the intense current was used very much more rapidly than in the second.

Experiment III. (Faraday's).—When a quantity current (large cells) and then an intensity current (small cells) were transmitted along the wire (1,100 miles), each current deflecting the needle to the same extent, no appreciable difference could be perceived in the rapidity of the current, each took about the same time, viz., eight-tenths of a second (using a galvanometer).

Experiment IV. — In the experiments at Lothbury the needle at the distant end was observed to deflect with little jerks or pulsations, not with the steady movement usually observable. This same effect occurred to-day, and in order to

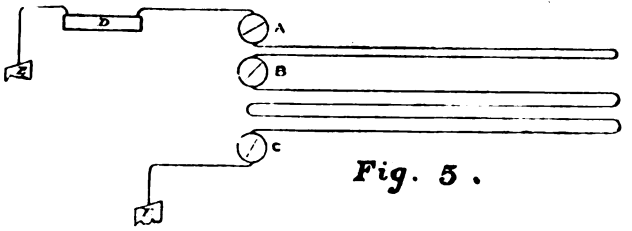

Fig. 5.

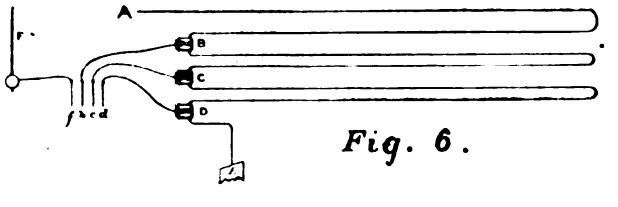

Fig. 6.

test whether it was attributable to an electrical or mechanical cause, I placed a "pecker"* at the distant end in place of the galvanometer. The armature of the pecker was attracted with a steady movement, and showed no signs of pulsations, from which it may be inferred that these pulsations are due to the mechanical movement of the needle, and not to any electrical effect.

Experiment V.—In order to record more accurately the results of experiment (2) I made use of the following arrangement :—

At B, C and D peckers were placed which by the attractions

* These experiments were made for Mr. Latimer Clark on some underground wires which were laid down in earthenware pipes between London, Manchester, and Liverpool, by the Electric Telegraph Company, along the London and North-Western Railway, in 1853-4.

* In the early days of telegraphy relays were called "peckers," from the peculiar form of the contact points.

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of their armatures brought into action local currents making marks at *b*, *c*, and *d* by the fine steel wire resting upon chemically prepared paper in the same way as we adopted in Lothbury. The wire *b* was in connection with pecker B 374 miles off, *c* with pecker C 750 miles off, and *d* with D 1,100 miles off. Wire *f* was in connection with a seconds pendulum which made a mark upon the paper at every second, and so measured off the paper into a scale of seconds.

Four currents of 560, 480, 336, and 200 cells were consecutively sent through the wire, and their effects recorded upon the paper revolving beneath the wires or needles *b*, *c*, and *d*. The contacts at A were too irregular to enable us to record with any accuracy the periods of transmission between A and B. We must therefore only rely upon the other lengths, viz., between B and C, and C and D. There appears to be a small variation in the times of the appearance of the different currents, but this variation is so irregular, and apparently following no direct law, that we may rather consider it due to the imperfection of our instruments than to any difference in the velocity of the currents. We may consider the times of transmission of all these currents to be equal, as was also observed with the galvanometer; but there is this remarkable difference between the appearance upon the electromagnet and upon the needle—that, while the current upon the one (the needle) appeared in eight-tenths of a second, it did not appear upon the electromagnet for nearly 3 seconds!

N.B.—This experiment was subsequently repeated with greater care, and with Bain's chemical recording instruments. The results were completely confirmed, and submitted to Faraday by Mr. Latimer Clark.

[The above experiments have not appeared in print before, and I publish them now in order that it may be seen how early in the history of the practical application of electricity our attention was directed to self-induction. W. H. P.]

G. P. O., Nov. 14, 1888.

ON THE MAGNETISATION OF IRON AND OTHER MAGNETIC METALS IN VERY STRONG FIELDS.*

BY J. A. EWING, B.SC., F.R.S., AND WILLIAM LOW.

Early in 1887 the authors communicated to the Royal Society the results of experiments made by subjecting iron to strong magnetic force by placing the sample, in the form of a bobbin with a short narrow neck and conical ends, between the pole-pieces of an electromagnet. The experiments have been continued and extended by using much stronger magnetic forces and by testing samples of nickel, cobalt, and various steels, as well as wrought iron and cast iron. The large magnet of the Edinburgh University Laboratory, kindly lent by Prof. Tait, was used throughout the experiments, and allowed the authors to effect a high concentration of the magnetic force by using bobbins the necks of which had a cross-sectional area of (in some cases) only $\frac{1}{1500}$ of the cross-sectional area of the magnet cores. By this means the induction $\mathfrak{B}$ was raised to the following extreme values:—

In wrought iron	45,350 c.g.s.
„ cast iron	31,760 „
„ Bessemer steel	39,880 „
„ Vickers' tool steel	35,820 „
„ Hadfield's manganese steel	14,790 „
„ nickel	21,070 „
„ cobalt	30,210 „

The induction was measured by means of a coil consisting of a single layer of very fine wire wound upon the central neck of the bobbin. Outside of this coil, at a definite distance from it, a second coil was wound, and the magnetic force was determined in the annular space between the two. In a Paper communicated to the Manchester meeting of the British Association, the authors showed that if the force so measured could be proved to have the same value as the magnetic force within the metal neck itself, it would follow that the intensity of magnetism $\mathfrak{J}$ had begun to diminish under the action of excessively strong fields, in the manner which Maxwell's extension of the Weber-Ampère theory of molecular magnets anticipates. In the present Paper the authors discuss at some length the question of how far the magnetic force within the metal is fairly measurable by the magnetic force in the ring of surrounding air, and they show that with the form of cones originally used the force within the metal must have been less than the force outside, by an amount probably sufficient to explain the apparent decrease of $\mathfrak{J}$. The form of cone suited to give a uniform field of force with sensibly the same value in the metal neck and round it is investigated; and experiments are described in which the condition necessary for a uniform field was satisfied. The results of these experiments are conclusive in showing that no considerable change takes place in the value of $\mathfrak{J}$ (in wrought iron) when the magnetic force is varied from about 2,000 to 20,000 C.-G.-S. units. Throughout this range of force the intensity of magnetism has a sensibly constant value of about 1,700 C.-G.-S. units, which is to be accepted as the saturation value for wrought iron. The term saturation may be properly applied in speaking of the intensity of magnetism, but there appears to be no limit to the degree to which the magnetic induction may be raised.

To produce the greatest concentration of force upon the central neck, the converging pole faces should have the form of cones, with a common vertex in the middle of the neck, and with a semi-vertical angle of 54° 44′. This form, however, does not give a uniform field in the neighbourhood of the vertex. To secure that, the condition is that d^2F/dx^2, d^2F/dy^2, and d^2F/dz^2 shall vanish, F being the magnetic force at the vertex, which is due mainly to the free magnetism distributed over the pole faces. The condition for a uniform field is satisfied when the cones have a semi-vertical angle of 39° 14′. When this form is given to the cones, the magnetic force in the air immediately surrounding the central neck may be taken as sensibly equal to the force within the neck, and it therefore becomes practicable to measure the relation of the induction to the force producing it, that is to say, the magnetic permeability.

The greatest attainable concentration may be calculated by assuming the pole faces to be saturated, when the cones are such as to have maximum concentrative power (semi-vertical angle = 54° 44′). Under these circumstances the magnetic force at the vertex due to the free magnetism on the conical faces is—

$$18{,}930 \log_{10} \frac{b}{a},$$

where *b* is the diameter of the poles at the base of the cones, and *a* the diameter of the central neck.

The following are probable values of the intensity of magnetism when saturation is reached in the particular metals examined:—

	Saturation value of $\mathfrak{J}$.
Wrought-iron	1,700
Cast-iron	1,240
Nickel (with 0·75 per cent. of iron)	515
Nickel (with 0·56 per cent. of iron)	400
Cobalt (with 1·66 per cent. of iron)	1,300

Experiments were also made with specimens of Vickers' tool steel, and other crucible steels, Whitworth's fluid-compressed steel, Bessemer steel, Siemens steel, and Hadfield's manganese steel. This last material, which is noted for its extraordinary impermeability to magnetic induction, was found to have a constant permeability of about 1·4 throughout the range of forces applied to it—namely, from 2,000 to nearly 10,000 C.-G.-S.

The results are exhibited graphically by curves drawn in Rowland's manner to show the relation of the permeability to the magnetic induction. In the highest field examined the permeability of wrought-iron had fallen to about 2.

* Abstract of a Paper read before the Royal Society, Thursday, 22nd November, 1888.

AN ELECTRIC CRANE BY MESSRS. CROMPTON AND CO.

At Messrs. Herrmann and Co.'s wood-working factory in Dod-street, Limehouse, there is now in use a portable and self-propelling crane, driven by an electric motor. The premises, which are of an extensive character, are lit with about 300 incandescent lamps from a Crompton 18-unit dynamo, giving 110 volts. This machine also supplies the current by which the crane is worked. The crane is used for unloading timber from barges lying in the canal at the back of the building, and is required to transfer the load to any one of the several rooms on each floor of the warehouse. For this purpose the crane is mounted upon the flat roof of the building, where it runs on rails, which also traverse a wooden staging projecting over the canal. There is a sharp curve in one part of the track.

The specification required that the motor should lift 15cwt. as a maximum load, and should raise 10cwt. at the rate of 80ft. a minute, that it should travel on the track at the rate of 80ft. per minute, and should slew at about the same speed. It was further specified that, if required, any two of these motions should be performed at the same time; but it was not required to hoist, travel

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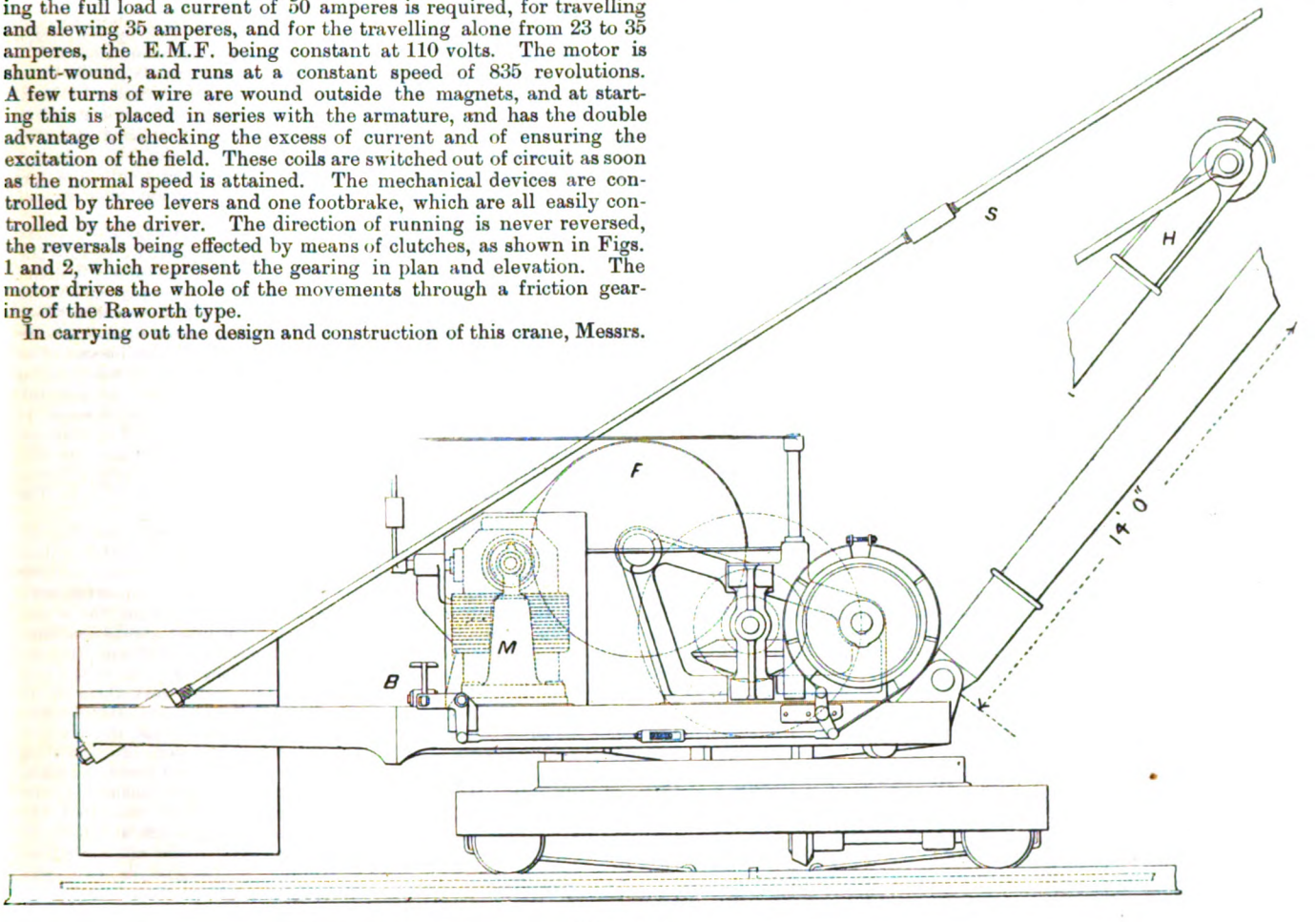
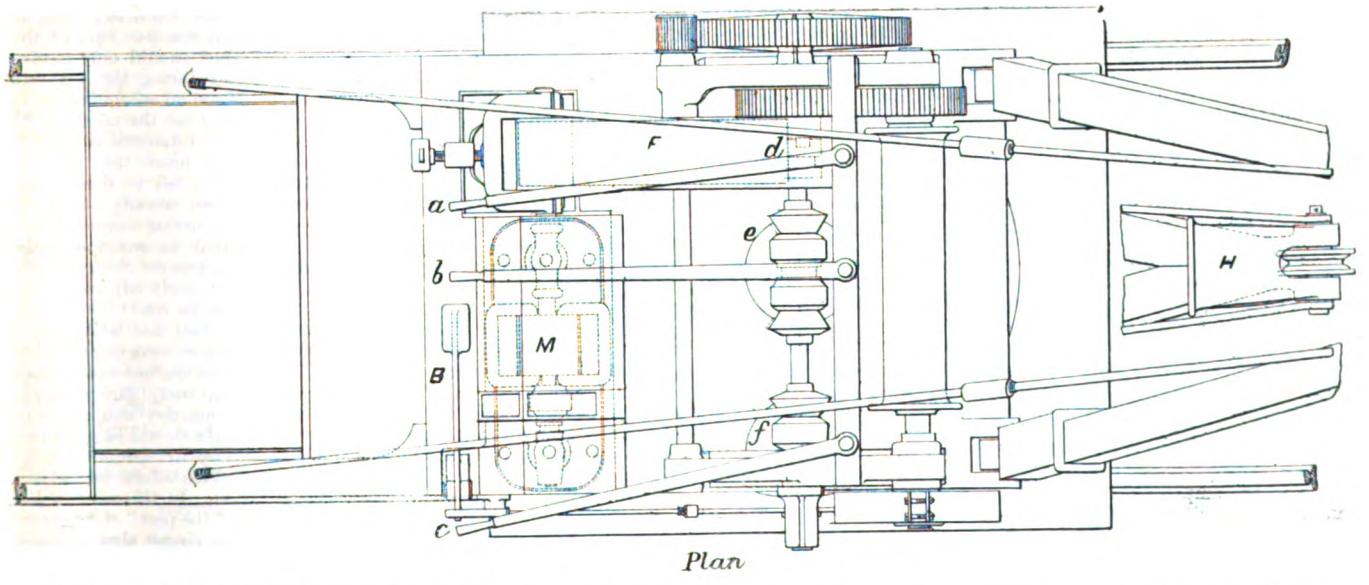
and slew all at once. As a matter of fact, the plant supplied by Messrs. Crompton has exceeded the requirements of the specification in every particular. The motor is capable of lifting several hundredweight in excess, it does its work more rapidly, and is able to undertake all three operations at the same time. For hoisting the full load a current of 50 amperes is required, for travelling and slewing 35 amperes, and for the travelling alone from 23 to 35 amperes, the E.M.F. being constant at 110 volts. The motor is shunt-wound, and runs at a constant speed of 835 revolutions. A few turns of wire are wound outside the magnets, and at starting this is placed in series with the armature, and has the double advantage of checking the excess of current and of ensuring the excitation of the field. These coils are switched out of circuit as soon as the normal speed is attained. The mechanical devices are controlled by three levers and one footbrake, which are all easily controlled by the driver. The direction of running is never reversed, the reversals being effected by means of clutches, as shown in Figs. 1 and 2, which represent the gearing in plan and elevation. The motor drives the whole of the movements through a friction gearing of the Raworth type.

In carrying out the design and construction of this crane, Messrs. Crompton have been ably assisted by Mr. Hollick, acting on behalf of Messrs. Herrmann. After the crane was completed and erected, many points of detail in construction were found to require slight modifications or strengthening, and on all these points Mr. Hass, who is Mr. Herrmann's representative, gave further able assistance. The result has, in the end, been eminently satisfactory. Not only has the specification been completely accomplished, but, as we have already mentioned, the requirements therein set forth have been considerably exceeded. The crane has now been in constant use for nearly two months, and Mr. Hass informs us that it has worked to his entire satisfaction. We understand that the sole reason why an electric crane was thought of was the fact that the



Elevation



Plan

M Motor. H Head of Crane. F Friction Wheel. S Stay. B Brake foot-lever, used for lowering. *a* Hoisting lever. *b* Travelling lever. *c* Slewing lever. *d* Hoisting fork-clutch. *e* Travelling cone friction clutches. *f* Slewing cone friction clutches.

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insurance offices declined to renew the policy if a steam travelling crane was placed in the position required. The arrangement of gear on this crane would be readily applicable to derrick cranes and other kinds of hoisting gear, travellers, &c., and it is obvious that there is a great saving of wear and tear, as compared with the ordinary portable steam cranes. We confidently look for a considerable extension of electrical engineering in the direction indicated.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

On Thursday, the 22nd inst., the meeting of this society was held in the Theatre of the Institution of Civil Engineers, Westminster, the President (Mr. Graves) in the chair.

The SECRETARY (Mr. Webb) having read the minutes of the last meeting,

The PRESIDENT announced that, owing to some formalities in connection with the Joint Stock Companies Act, the name of their society could not be changed to the Institute of Electrical Engineers until January next. He then called upon

Mr. HENRY EDMUNDS, M.S.T.E., to read his Paper on

"A System of Electrical Distribution."

[*The Paper appeared in the last number of The Electrician.*]*

After the reading of the paper, the discussion was opened by

Mr. RECKENZAUN, who congratulated the author on the ingenious manner in which he had carried out his problem. He had the privilege of seeing the apparatus at work a few weeks ago at Mr. Edmunds' place at Hatton-garden, and he was very much surprised at its accurate working. The only objection to the apparatus was that it appeared to be too delicate when placed in a station where the accumulators might be in proximity to the apparatus, for there was a possibility of the fumes causing the metal to get tarnished. He was very much surprised to find that the sparking was almost invisible even with a current of 70 amperes. He believed it would be difficult to charge at 2·25, because the counter electro-motive force of the battery was practically that, and sometimes a little more, owing to the hydrogen gas which was nearly always on the surface of the plates, and generally produced a fictitious electro-motive force, which was frequently above 2·25 volts.

Mr. PREECE said there was something remarkably enticing in this system. Broadly, the principle had about it the merit not only of novelty but of access, and it also had been worked out in a manner that reflected the very highest credit on Mr. Edmunds. He thought, however, that it was still in the experimental stage, where it was laden rather with excrescences, that would have in practice to be cut off. Mr. Edmunds deserved a considerable amount of thanks for bringing a new thing before them in order that they might think it out for themselves. He attributed the absence of sparks to the absence of self-induction in the circuit. He should like to have some further explanation from Mr. Edmunds as to the means by which, without a governor, without a compound winding, without any contrivance of any kind, he succeeded in maintaining a constant current in his circuit. Mr. Edmunds said it was so, and he supposed they were bound to believe it; but there was something peculiar about it, and something that required examination. As to the automatic switch, he must say, as a practical man, that he disliked the introduction of any complicated apparatus to add to the complication of an already complicated system, and that the process should be simplified as much as possible. He could not help thinking a misconception existed about the behaviour of batteries when charged and when discharged. The curve showing the rise of voltage hour by hour as the battery was charged was a curve perfectly familiar to him; but there was another curve wanted, and that was the curve of current. If they took a record of the variation of voltage during the time a battery was charged, and also a variation of current, they would find that while the voltage was increasing the current was diminishing. When they discharged they discharged a battery at a very much lower voltage, and the general impression of the great majority of men in that room was that under these circumstances they got a great loss of energy. Well, they did not. As a matter of fact a secondary battery had one remarkable point connected with it that had raised very little attention, and it was this, that a battery was a kind of automatic governor, that the internal resistance of the battery varied with the current that went through it, so that if they discharged a battery at one ampere they got one resistance, and if they discharged at ten amperes they got very nearly one-tenth of the internal resistance. The result was although unquestionably the voltage of discharge was very much lower than the voltage of charge, the number of watts in a given time was practically the same; so that if they put, say, 300 amperes into a battery, they could, when they discharged it with a small current, get nearly the whole of their energy out of it. He had succeeded in extracting from a battery 98 per cent. of the energy put in, and that was due to the fact that the internal resistance varied with the current of discharge (applause).

* A detailed account of the working of the "distributor," which is not given in Mr. Edmunds' paper, will be found on page 110 of the present issue.

Mr. W. L. MADGEN: I do not wish to say anything tending to revive the discussion between the adherents of the alternating and battery transformer systems, as both parties seem to have buried the hatchet, determined to work their respective methods, and leave time to show which is best; but a marked change has taken place in the aspect of the battery transformer system since the discussions on Mr. Crompton's and Mr. Kapp's papers. It was then implied that as the function of the cells would be principally that of "potential reducers," the entire loss by conversion would not be incurred. But that position has now been abandoned, and I understand it to have been made a rule that house-circuits are not to be connected with the battery at the same time as the primary or high-tension main. Mr. Edmunds seemed to justify the use of house-conductors of a lower grade insulation with his system than are now being generally used in connection with the alternating current service, but I do not suppose that the extra price for equally well insulated conductors will make very much difference, and the tendency to use less reliable is, at least, one which should not be encouraged.

Mr. D. C. BATE said it seemed not only would this system of secondary battery distribution not reduce but it was liable actually to increase the cost, not only over transformer systems but also over other battery systems. Here, if the batteries were discharged at more than an average amount of one-third of the maximum charging current, they would have a direct loss. Taking 70 amperes as being put in, the battery must not discharge more than 23 amperes, or there would be a considerable reduction instead of an increase. That necessitated very much larger cells than if, as was done on the Colchester system, the batteries were allowed to discharge at their full rate, and then replaced by others of an equal capacity. The solenoid to cut-out batteries by reversal of the dynamo current appeared an unnecessary complication if the station was intended to run for 24 hours. He did not understand Mr. Edmunds' engine running without a governor, and he hoped that he would be able to give them some more information on that point.

Mr. KAPP said Mr. Preece had spoken about the system of working the steam engine without a governor as if it were something doubtful or dangerous. Well, Mr. Berenstein had done it years ago, and there was nothing doubtful about it at all. It was a method of working based upon the well-known fact that, with a constant field and constant torque (the steam pressure on the piston being constant), the current must also be constant. On this account the engine adopted by Mr. Edmunds would give no trouble; but he thought that it would give trouble in another way, viz., in the coal bill. Engines were very patient things. They might work them up to different degrees of expansion and different speeds and they would consume the same amount of steam per horse-power; but there was a limit to their patience, and if they worked an engine just crawling around, the weight of water per horse-power would considerably increase. The reason was that the steam had time at each stroke to condense in the cylinder. The great advantage of high-speed engines was that the steam had no time to condense. The cylinder, although it might be of a metal which conducted heat very quickly, would not have time to take away many heat units. Working the engine in that way was almost as good as if the cylinder was made of a non-conducting material. Running an engine slowly was a comfortable thing for the man in charge, but it was not good for the man who had to pay the coal bill. It was therefore a questionable advantage to work in this manner, although the working was perfectly possible on scientific grounds. He should like to put a question to Mr. Edmunds. That gentleman had said that his generating plant, boilers, engines and dynamo need only be one-third the size of what would be required in a battery system arranged on what was generally known as the Colchester plan—two batteries, one charging whilst the other was working the local circuit. On first looking at it it seemed right, but he was not quite sure that it was so. One of the conditions of working these batteries was that they should only receive small increments of charge for two minutes, and during the next six minutes discharge these, in order that there should be no accumulation of charge which would raise the electromotive force beyond the middle part of the curve. If that was so, he could not see how Mr. Edmunds saved anything over a direct supply system. If, on the other hand, they allowed the cells to accumulate a charge, then the argument fell to the ground that the batteries were used in a better way than usually; and, in fact, the circumstance that Mr. Edmunds put a regulating magnet which came into action upon a rise of potential, showed that he anticipated the batteries would accumulate a charge and oppose a greater electromotive force than 2·2 volts. Could this magnet be so delicately adjusted as to come into play with, say, 2·25 volts? If that was so he could understand that the lamps could be worked to a higher voltage than that labelled, and the light would be exceedingly steady. But then they were on the other horn of the dilemma, namely, during the daytime the engines would work very much under power. They lived, as in an ordinary direct supply system so to speak, from hand to mouth, for the consumer would take in the evening as much as the engine could produce. He should like to draw attention to the very beautiful electro-magnet used by Mr. Edmunds in his voltage regulator. He thought he had seen it elsewhere before, but, at any rate, the device was worthy of their consideration. In this magnet Mr. Edmunds had got over what Mr. Preece had called "the pest" of magneto-electric apparatus, viz., self-induction. They had one circuit always closed, and therefore in that circuit there was no sparking, and in the other circuit of high resistance there was also no sparking when the contact was opened. When the shunt current flowed the core was not magnetised, and therefore on breaking it the spark was only that due to the small current flowing through an inert resistance. On closing when the core was magnetised they could, of course, not have any sparking, so that really in this case they had an electro-magnetic instrument which might be put in and out of action and giving all the advantages of the magnet, and yet without its disadvantages of self-induction. He was rather sorry that the motor generator had got into the diagram. They did not care to have

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machinery in a house, not even in a theatre if they could help it, and he hoped that such a generator would not be used. One of the advantages of Mr. Edmunds' system was that he could have perfect insulation. With a motor generator they could not get this insulation.

Mr. A. P. TROTTER said he could quite corroborate what Mr. Kapp had said about the constant current. He remembered some time ago taking great pains to make an accurate constant-current regulator, and found that it was much better to throw off the governor and to let the engine go ahead. To what extent that could be done on a large scale he was not able to say. It was an extremely ingenious system, but they would like to look at the figures. Great stress had been laid upon the insulation and that the main was quite apart from the batteries, but as he understood the matter six thousand volts went fooling around that beautiful arrangement (laughter). Still, he should like to know in inches the actual thickness of insulation. The main, he apprehended, got inside the box with the other contacts (laughter). He did not like to be flippant about the thing, for he could not but admire the extreme ingenuity which Mr. Edmunds had displayed.

Professor FORBES said they were all agreed that the subject which had been introduced to them was one which was absorbing attention more now than it had done, and was also one upon which they were looking to such fertile inventors as Mr. Edmunds to give them new materials in the future. Having now become thoroughly satisfied with the satisfactory performance of one system of distribution, they naturally looked forward to the time when they should be able to distribute on an alternative plan. The chief difference which he noticed in a general principle between Mr. Edmunds' system and other systems which had been proposed for using secondary batteries was in this ingenious plan of charging and discharging cells alternately at short intervals of time. In other systems of using accumulators trouble arose from the fact that when they put the fully charged cells into the circuit they had a higher voltage for a short time, and one or two cells had to be cut out. The complicated devices which had been attempted to be used to accomplish this end had, so far as he had seen them at present, not been successful. There were some, he believed, which had lately been brought out, but which he had not yet investigated. But Mr. Edmunds's seemed to be the first one free from that difficulty. It seemed to him that in this system batteries were never used at a higher charge than half their charge, and it also appeared that they were depending upon the capacity of the battery, and therefore they were depending with those batteries upon only half the charge that they were really capable of using. He knew that when that was put by some other speaker, Mr. Edmunds made some expression of dissent, but he (Prof. Forbes) failed to see his way out of the difficulty, and he should be glad to hear Mr. Edmunds' answer to that. Incidentally he was extremely pleased to hear Mr. Edmunds responsible for a statement that he had lamps which were working with two and a-half watts per candle-power, and whose light was considerably over one thousand hours. This was news to him, and he should be glad to know something more about the lamps. When Mr. Edmunds was describing his regulating arrangement, it occurred to him that this was exactly the converse of the result in motor work which was first announced by M. Deprez, that was to say, when they had a series motor or a motor excited by a constant current, they might vary the load as much as they pleased and the volts would go up, but the current would remain perfectly constant as long as the pressure remained so. Now that was the converse thing as applied to the dynamo. That was the case of a dynamo working against a constant pressure, and this was the case of a dynamo being driven by a constant pressure from the steam engine. He should like fuller details about the method of introducing a second and third engine to assist the work. It seemed that Mr. Edmunds had passed it over a little lightly, and that it was not quite such a simple affair as he would lead them to believe. The weakest point, as it seemed to him, in the necessary apparatus in the system was in that make and break which Mr. Kapp had approved of so much. It appeared to him (the Professor) that in an apparatus which had to be constantly at work day and night without attention in the consumer's house, that anything in the shape of a make and break was to be condemned at once. In conclusion, he thought the first general feeling they had about this system was that there was a little too much complexity in the apparatus which had to be put into every individual house, and it would have been well if Mr. Edmunds could have given them some approximate notion of the cost of this apparatus, which had to be added to all the ordinary apparatus with which a house was installed. If he had been a little critical it was not his intention. He was extremely delighted with the general scheme put before them; and he was certain that every one would be looking forward to the development of Mr. Edmunds' system, and seeing how it actually worked out in commercial practice.

Mr. EDMUNDS said he had a great many questions to answer, and he should like to reply to them at their next meeting.

The CHAIRMAN presumed that there would be no objection to Mr. Edmunds doing so, and at their next meeting, on the 13th December, Mr. Edmunds could reply to the whole of the observations.

The discussion was then adjourned.

Exports of Telegraphic Wires and Apparatus connected therewith.—Our exports of telegraphic wire and apparatus connected therewith continue to show a most unsatisfactory falling off. The following are comparative figures for October, and for the ten months ended October 31, taken from the Board of Trade returns issued this week :—

Exports.	1888.	1887.	1886.
October	£17,038	£31,475	£60,467
Jan. 1 to Oct. 31	£414,177	£688,539	£951,088

THE ELECTRICIANS' DIRECTORY AND HANDBOOK FOR 1889.

The 1889 edition of this well-known DIRECTORY and HANDBOOK, which claims to be the best and most reliable international medium of intercommunication devoted to the electrical and allied trades (containing, as it does, a large number of useful statistics and tables of considerable interest to those engaged in electrical pursuits all over the world) is nearly ready for press. The Publisher notifies that the time for receiving new names, addresses, corrections, and advertisements will shortly expire, and that firms and individuals requiring their names inserted in the book should send at once.

The price of the Directory, when ready, will be Four Shillings, prepaid.

All further particulars will be forwarded by the Publisher upon receipt of inquiry.

BOOKS, &c., RECEIVED.

"Traité de Télégraphie Sous-Marine." By E. WÜNSCHENDORFF. (Paris : Baudry et Cie.)

"Étude Théorique des Transformateurs." (Extracted from *l'Electricien.*) By CHARLES JACQUIN. (Paris : G. Masson.)

"Technology Quarterly." Vol. II. No. 1. (Boston).

"The Daft System of Electrical Railway Propulsion." (New York.)

Gent and Co.'s "Illustrated List of Galvanic and Other Instruments used in the Practice of Electro-Therapeutics."

"Die Erzeugung und Verteilung der Elektrizität in Zentral Stationen." By Dr. MARTIN KRIEG. Vol. II. (Magdeburg: A. and R. Faber.)

"Die Accumulatoren für Elektricität." By EDMUND HOPPE. (Berlin : Julius Springer.)

"Kalender für Elektrotechniker." By F. UPPENBORN. (Munich and Leipzig : R. Oldenbourg, 1889.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, November 30th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "The Covered Service-Reservoir of the Southampton Corporation." By E. T. HILDRED, Stud. Inst. C.E. "On the New High-Level Storage Reservoir for the Grand Junction Waterworks Company at Hanger Hill, Ealing." By H. ASHLEY, Stud. Inst. C.E.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Amateur Concert. Ladies' night. St. James's Hall Restaurant.

MONDAY, December 3rd.

SOCIETY OF ENGINEERS.

7:30 p.m. A Paper will be read at the Westminster Town Hall on "High Pressure Steam and Steam Engine Efficiency." By Mr. W. WORBY BEAUMONT, M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. "Light and Colour." Capt. W. de W. ABNEY, C.B., F.R.S. (Second Lecture.)

TUESDAY, December 4th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "The Influence of Chemical Composition on the Strength of Bessemer Steel Tyres." By Mr. J. OLIVER ARNOLD, F.C.S. At this meeting the first ballot of the session will be taken.

ROYAL VICTORIA HALL.

8 p.m. Lecture, "Nature's Hot Springs." By Mr. S. RIDEAL.

WEDNESDAY, December 5th.

CITY AND GUILDS OLD STUDENTS' ASSOCIATION.

7:45 p.m. General Meeting at the Central Institution, Exhibition-road. A Paper will be read on "Aluminium," by Mr. W. M. HELLER.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Graphophone." By Mr. HENRY EDMUNDS.

THURSDAY, December 6th.

SOCIETY OF TELEGRAPH ENGINEERS.

8 p.m. Students' Meeting. "Electric Light Measurements." By Messrs. A. H. BATE and GIMINGHAM.

SATURDAY, December 8th.

PHYSICAL SOCIETY.

3 p.m. "On Some Facts Connected with Systems of Scientific Units of Measurements." By Mr. T. H. BLAKESLEY.

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
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„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

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THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received.

CONTENTS OF THE CURRENT NUMBER.

Notes 95
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 100
Self-Induction and Retardation. By W. H. Preece, F.R.S. Illustrated 101
On the Magnetisation of Iron and other Magnetic Metals in Very Strong Fields. By J. A. Ewing, B.Sc., F.R.S., and William Low 102
An Electric Crane by Messrs. Crompton and Co. Illus. ... 102
The Society of Telegraph Engineers and Electricians—
"On a System of Electrical Distribution." By H. Edmunds. *Discussion.* 104
Meetings of Scientific Societies. 105
The Pacific Cable Conference 106
Obituary—
M. Lucien Gaulard 107
Physical Society—
"The Suppressed Dimensions of Physical Quantities." By Prof. A. W. Rücker, F.R.S. 108
The Edmunds "Distributor." Illustrated 110
Legal Intelligence—
King, Brown and Co. *v.* The Anglo-American Brush Electric Light Corporation 111
American Notes 114
Correspondence 116
The Woodhouse and Rawson Dynamo. Illustrated 118
Companies' Meetings, &c.—
Crompton and Co. (Limited). 118
Pilsen-Joel and General Electric Light Company 119
Blackpool Electric Tramway Company 120
Maxim-Weston Electric Co... 120
New Companies Registered ... 121
City Notes, &c. 121
Companies' Share List 121

"THE ELECTRICAL WORLD" IN THE UNITED KINGDOM.

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THE PACIFIC CABLE CONFERENCE.

The Pacific Telegraph Cable scheme depends on so many improbable contingencies that at first sight it seems hardly worth while to treat the project seriously. First of all, the Pacific Ocean has not yet been explored, or explored only with the result of demonstrating how hazardous would be any cable-laying operations on a large scale in those waters. Next, a very heavy subsidy from the British, Canadian and Australasian Governments has to be obtained. And, lastly, with these adverse conditions yet unsatisfied, the financial public will have to be induced to subscribe—or promise to subscribe—the necessary funds to defray the cost of an undertaking of which the success is extremely problematical, and the commercial failure almost certain. Nevertheless, there were some features of the conference held last week to discuss this subject deserving the attention of those who are well-wishers of cable-laying enterprise, one of which was the perfect candour of the noble lord who presided, and who, to the best of his ability, explained the objects of the meeting. They were assembled, said Lord Winchilsea, simply as men of business to set forward their own interests as traders; and he intimated pretty plainly that

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nobody else's interests would receive much consideration at their hands. They had to consider only whether the existing means of communication with the Australasian colonies were sufficient, whether they were safe, and whether they were as cheap as they ought to be.

Now, had these propositions been placed before a conference of experts, or of men with any recognised standing in the business of submarine telegraphy, the worthy chairman would have been promptly reminded that several other conditions vital to the problem under discussion would require a strict examination—such, for example, as whether a cheap rate could be made remunerative; whether a deep-sea cable is any safer for being out of reach; and whether, with existing cables not fully employed, their insufficiency is proved by there being room for another on a different route. But, unfortunately, at the Cannon-street Hotel conference the audience, so far as we can gather, were not of that character; and, judging by the language of those who took part in the speech-making, were chiefly colonialists, or customers of the present cable companies anxious to see the Australian and New Zealand rates cheapened, but not at all mindful of how it is to be done, or of who bears the risk, so long as the scheme offers some promise of lessening their business expenses.

Of course there was the usual talk about forging another link in the chain which binds the mother country to her colonies; but talk of that description, however commendable it may be, has never yet caused a cable to be laid, and never will, except when there is a proved necessity for it. The proofs adduced in this instance are far from being convincing. By some untoward accident both the two Australasian cables have been rather seriously interrupted of late; but they were promptly repaired, and their past history shows as good a record of stability as any cables that have ever been laid. Besides this, a third cable is about to be submerged, affording an additional link which is not likely to be broken simultaneously with the other two. The chain has been forged link by link until it has reached this furthermost colony of the Empire; and the choice of route has been more a matter of geographical and commercial necessity than of calculation. But until now the Pacific has been avoided for practical reasons sufficiently cogent. Its depth is enormous, and its bottom is known to be traversed by ridges which would render the life of a cable bridging the intervals exceedingly insecure. An experiment of that kind, although profoundly interesting, would be attended with great risks, and as nothing was to be gained by it, none of the established cable companies have thought it expedient to extend operations in that direction. Judged, therefore, by practical and prudential considerations, the project for connecting Australia with England through Vancouver and Canada, by way of the Pacific, is not an attractive one. But as the public are invited to support it on other and higher grounds, we will do our best to examine them and see what they amount to.

Reduced to their true dimensions the arguments for this Pacific route are chiefly these, namely, that the construction of the Canadian Pacific line of railway and telegraph has rendered that route of great imperial importance, requiring it to be supplemented and completed by a connecting cable between its western extremity and the Australian colonies; and, secondly, that this cable being in very deep water, would be safe from the depredation of any hostile cruiser. As regards the first of these propositions, we may observe that the Canadian Pacific Railroad would be useful to us, if useful at all, to convey troops for India rather than to Australia; and is, moreover, flanked the whole distance by the foreign, and possibly unfriendly, territory of the United States—a fact which it is fair to point out, seeing that the advocates of the Pacific route object to the Eastern route because it passes over, or is in close proximity to, foreign territories. One gentleman went so far as to recommend the new scheme because "it would go across British territory entirely"—his idea seeming to be that Britannia not only rules the waves but owns all beneath them. We do not by any means undervalue the argument for independent routes; but its importance may easily be exaggerated. It ought not to be assumed that every foreign country is going to be an enemy; on the contrary, it might in many cases be argued, with just as much reason, that a foreign section will be inviolate because of its being on friendly soil. As a fact, however, the routes to the far East, as an examination of any telegraph map will show, is remarkably independent of foreign guardianship; and except for the hazards of naval warfare is practically unassailable.

This brings us to the point on which the Pacific cable promotors think themselves strongest. In case of war it would be extremely difficult, so it is alleged, to destroy the cable. Passing over the suicidal character of this contention, which condemns the cable to permanent loss if accidently broken, we may remark that the continuity of this or any other cable can be effectively destroyed without molesting its deepest portions. Why should an enemy's cruiser try to drag up a cable from the bottom of the Pacific when the object could be accomplished in shallow waters? And it happens that the intervening points of landing in the case of the projected Pacific cable would be singularly exposed to an attack of that kind; whereas the Eastern and Eastern Extension cables enjoy the advantage of being laid along routes most frequented by ships carrying the British flag. The simple fact is that all submarine cables belonging to belligerents will be remorselessly destroyed wherever they can be got at; and the only way in which English cables may escape interruption on the outbreak of hostilities is to lay them where English men-of-war are most likely to afford them protection. Obviously this kind of protection, such as it is, would cover a Pacific cable hardly at all; and unless some more urgent reasons of State for its construction can be adduced than those put forward at last week's conference, we suspect that neither the British Government nor the British public will lend any substantial assistance to the scheme.

OBITUARY.

M. LUCIEN GAULARD.

The death of M. Lucien Gaulard took place in Paris on Monday, the 26th inst. M. Gaulard was born in 1850, and was well-known in French and English scientific circles. His name is associated principally with the system of electrical distribution by secondary generators, which occupied his sole attention during the last six or seven years; his earlier efforts were devoted to various branches of electrical and chemical science. In 1881 M. Gaulard showed at the Electrical Exhibition in Paris his thermo-electric battery, which excited a great deal of attention. It was at this time that M. Gaulard was invited by Mr. Gibbs to come to London, and since then, up to the time of M. Gaulard's illness in the spring of the present year, he was a director of the National Company for the Distribution of Electricity by Secondary Generators (Limited). M. Gaulard was a member of the Society of Telegraph-Engineers, and was decorated by the King of Italy at the Turin Exhibition in 1884. He leaves a widow but no family.

The history of invention scarcely contains a more mournful story than that of M. Gaulard. To him, beyond all question, belongs the honour of having initiated one of the most brilliant and successful developments of electrical engineering. The fact that the idea itself already lay dormant in the records of

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the Patent Office cannot in the least detract from the merit of the man who first realised its value, and who, in spite of all difficulty, and in spite, it must be said, of the serious deficiencies of the particular method by which he sought to carry out his projects, forced the electrical world to recognise the immense importance of the alternate-current transformer. By a most unhappy fate, M. Gaulard contrived just to miss the one point of detail in the method of using his apparatus which involved the difference between commercial success and practical failure. Having thus missed his way, he had, in consequence, to suffer the mortification of standing idly by whilst other men were eagerly pursuing the track upon which he first set out. But though it is impossible not to feel the deepest sympathy for the unfortunate position in which M. Gaulard was placed, we believe it to be equally impossible to cast the blame of his misfortunes upon other shoulders. In actual life every man must abide the fortune of war with such fortitude as his individual temperament may permit. Unhappily, in this case, the strain proved at length to be greater than the mental equilibrium of the inventor could sustain. And notwithstanding the gleam of sunshine which the purchase of the American patent by the Westinghouse Company must have brought, yet in the early part of last summer his intellect became clouded, and it was found necessary to place him under restraint. His death has taken place just at the moment when the methods which he inaugurated are about to be applied upon a scale of hitherto undreamt of magnitude. In our correspondence columns will be found a letter from M. Cadiot, which expresses the feeling which has been called forth in Paris, and which will be very largely shared by the electricians both of this country and of America.

PHYSICAL SOCIETY.

At a meeting of the Physical Society, held on November 24, 1888, Prof. A. W. Reinold, F.R.S., President, in the chair, a Paper was read on

"The Suppressed Dimensions of Physical Quantities."

BY PROF. A. W. RÜCKER, F.R.S.

The author observed that there was no scientific novelty in what he had to bring before the Society, but he was of opinion that there was room for discussion whether the admitted facts with regard to the dimensions of physical quantities were expressed in the best possible manner by the methods in ordinary use.

In determining the dimensions of physical quantities, it was well known that there was often only a single equation containing two unknown quantities, which made the problem indeterminate. The difficulty was generally got over by assuming one to be a mere number, and then calculating the other. This would do very well if the dimensions were to be used merely for testing the comparability of the terms of a physical equation, but it would not be possible to arrive at a definition of the quantities from their dimensions, as could be done with the simpler physical quantities, such as acceleration, work, power, &c.

In the case of heat, the question arose what were the dimensions of temperature? Consider such an equation as $M L^2 T^{-2} = J M c \theta$, where L, M, T, θ are the units of length, mass, time and temperature, J the mechanical equivalent of heat, and c the specific heat of the substance considered. Taking c as a mere number, and putting it equal to unity, this becomes $[L^2 T^{-2} \theta^{-1}] = [J]$. It was clearly impossible to consider θ as a mere number, since the value of J depended on the units in which θ was measured, though on the other hand temperature, as measured on the ordinary thermometric scales, was indedendent of the units of time, length and mass.

In such a case two courses were open. Either some relation might be assumed to exist between θ and the three fundamental units, and hence the dimensions of θ determined, or it might be kept in the equations as a kind of secondary fundamental unit, necessary for thermal measurements, but not expressible in terms of the fundamental units on account of our ignorance, and the artificial methods by which we measured temperature.

The author observed that if our knowledge of the molecular dynamics of liquids and solids warranted us in extending to them the analogy of gases, temperature might be defined as the mean energy of translation of a molecule, or of a standard number of molecules which would give $M L^2 T^{-2}$ for its dimensions in terms of the fundamental units, and it would be independent of the properties of any special substance. It might be possible that when our knowledge became more extended some system of this kind might be adopted for the measurement of temperature.

Taking the temperature θ as a secondary fundamental unit, assuming the specific heat to be a mere number, and assuming the unit of heat to be defined with reference to the unit mass of water, the author obtains the following table of dimensions of thermal quantities :—

Name of Quantity.	Dimensions of Unit.
Quantity of heat	$[M\theta]$
Mechanical equivalent of heat	$[L^2 T^{-2} \theta^{-1}]$
Specific heat	0
Latent heat	$[\theta]$
Thermal capacity	$[M]$
Coefficient of expansion	$[\theta^{-1}]$
Coefficients of absorption and emission	$[M L^{-2} T^{-1}]$
Coefficient of conductivity	$[M L^{-1} T^{-1}]$
Entropy	$[M]$

The author then indicated a method of treating gravitational units, and pointed out that a distinction had to be made between the nominal unit of mass in such a system M and the real unit $M\gamma$, where γ was the numerical quantity expressing the acceleration of gravity in terms of the units of length and time employed. In such a system the three fundamental units were really length, time, and force, mass being a derived unit, M, subject to the condition that $\gamma L T^{-2}$ should represent a given concrete acceleration.

The cases of practical importance were force, work, power, and the mechanical equivalent of heat, and if the numerical measure of any of these quantities were multiplied by the numerical quantity γ transformations could be effected as usual by aid of the condition $\gamma L T^{-2} =$ constant.

Thus, if J_1 J'_γ and J''_γ were the numerical values of the mechanical equivalent of heat in an absolute, and two gravitational systems respectively

$$J [L^2 T^{-2} \theta^{-1}] = J'_\gamma \gamma' [L'^2 T'^{-2} \theta'^{-1}] = J''_\gamma \gamma'' [L''^2 T''^{-2} \theta''^{-1}],$$

or, if n n' were the numerical values of a power in an absolute and a gravitational system respectively,

$$n [M L^2 T^{-3}] = n' \gamma [M' L'^2 T'^{-3}].$$

The author pointed out that J was only independent of the unit of mass when the unit of force and the unit of heat were defined with respect to the same unit of mass, and it did not, therefore, hold good in the English system, where the unit of heat was defined with reference to the pound, while the force being measured in gravitational units was defined with reference to a mass of 32·2 pounds.

In the case of electrical and magnetic measurements the author pointed out that the question was one of much greater practical importance than in the case of thermal measurements. Maxwell had shown that the number of independent relations between electrical and magnetic units was one less than the number required to determine them completely.

The two systems in use, namely, the electrostatic and the electromagnetic, were founded on two different assumptions, which amounted to the suppression of the dimensions of specific inductive capacity and magnetic permeability respectively, and it was these suppressions which led to the differences, so perplexing to students, in the dimensions of electrical and magnetic quantities expressed in the two systems. The author, therefore, suggested the advisability of retaining symbols representing these quantities as secondary fundamental units in the tables of dimensions. If this were done the cause of the difference in dimensions would be brought prominently forward, and the factors required to transform from one system to the other would be clearly indicated.

If the proposed system were adopted, we should have, using Maxwell's notation,

$$[\mathfrak{D}] = [K \mathfrak{E}],$$
$$[\mathfrak{D}\,\mathfrak{E}] = [M L^{-1} T^{-2}],$$

and therefore,

$$[\mathfrak{D}] = \left[M^{\frac{1}{2}} L^{-\frac{1}{2}} T^{-1} K^{\frac{1}{2}}\right],$$
$$[\mathfrak{E}] = \left[M^{\frac{1}{2}} L^{-\frac{1}{2}} T^{-1} K^{-\frac{1}{2}}\right],$$

and, similarly,

$$[\mathfrak{H}] = \left[M^{\frac{1}{2}} L^{-\frac{1}{2}} T^{-1} \mu^{\frac{1}{2}}\right],$$
$$[\mathfrak{B}] = \left[M^{\frac{1}{2}} L^{-\frac{1}{2}} T^{-1} \mu^{-\frac{1}{2}}\right].$$

By means of these relations all the units could be expressed in terms either of M, L, T, K, or of M, L, T, μ, and the dimensions in M, L, T, would be those of the electrostatic and electromagnetic systems respectively. For by Maxwell's equations (7) "Electricity and Magnetism," Vol. II., page 243, 2nd edition,

$$[\mathfrak{D}] = [e L^{-2}].$$

Therefore

$$[e] = \left[M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1} K^{\frac{1}{2}}\right],$$

and by equation (9)

$$[\mathfrak{B}] = [m L^{-2}].$$

Therefore

$$[m] = \left[M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1} \mu^{\frac{1}{2}}\right],$$

and from the dimensions of $[e]$ and $[m]$ those of all the other units could be found.

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Maxwell had given a table in which the dimensions of each of the electrical and magnetic units were expressed in terms of L, M, T, and of either electrical quantity, e, or strength of magnetic pole, m. The author's suggestion merely amounted to choosing K and μ instead of e and m, as the two unknown quantities, in terms of which the units should be expressed, which would make the dimensions in L, M, T, the same as those of the electrostatic and electromagnetic units respectively.

The author suggested that quantities expressed in terms of K and μ respectively should be indicated by the suffixes s and m, when it was necessary to indicate the distinction, as for example, e_s and e_m.

By equating two such expressions for the same quantity, or by using any general relation between any two of the derived quantities, we should obtain a necessary relation between the dimensions of the secondary fundamental units in terms of the fundamental units.

Thus from Maxwell's equations (11) or (12) (*loc. cit.*)

$$[e\,m]=\left[\mathrm{M\,L^2\,T^{-1}}\right].$$

Expressing e in terms of K and m in terms of μ, we should have

$$[e\,m]=\left[\mathrm{M^{\frac{1}{2}}\,L^{\frac{3}{2}}\,T^{-1}\,K^{\frac{1}{2}}}\right]\times\left[\mathrm{M^{\frac{1}{2}}\,L^{\frac{3}{2}}\,T^{-1}}\mu^{\frac{1}{2}}\right]$$
$$=\left[\mathrm{M\,L^2\,T^{-1}}\right];$$

whence
$$\left[\mathrm{K^{\frac{1}{2}}}\mu^{-\frac{1}{2}}\right]=\left[\mathrm{L\,T^{-1}}\right].$$

It was evident that such a relation must exist, for since only one equation was wanting to determine the units completely in terms of L, M, T, it was clear that there could not be two independent methods of expressing them.

The author, after giving a series of examples illustrating the advantages of his system in effecting transformations from one system of units to another, gave the following table showing the dimensions of the various electrical units in terms of L, M, T, K, and L, M, T, μ, respectively. Putting K = 1 gives the ordinary electrostatic dimensions, and putting $\mu = 1$ the dimensions in the ordinary electromagnetic system :—

Name of Quantity.	Symbol.	Dimensions in Terms of L, M, T, and K.	Dimensions in Terms of L, M, T, and μ.
Quantity of electricity	e	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}}\mu^{-\frac{1}{2}}\right]$
Electrical potential	E	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{-\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-2}}\mu^{\frac{1}{2}}\right]$
Quantity of magnetism	m	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,K^{-\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{\frac{1}{2}}\right]$
Electrokinetic momentum of a circuit	p		
Electric current	c	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-2}\,K^{\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{-\frac{1}{2}}\right]$
Magnetic potential	Ω		
Electric displacement	$\mathfrak{D}$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{\frac{1}{2}}}\right]$	$\left[\mathrm{L^{-\frac{3}{2}}\,M^{\frac{1}{2}}}\mu^{-\frac{1}{2}}\right]$
Surface density			
Electromotive force at a point	$\mathfrak{E}$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{-\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-2}}\mu^{\frac{1}{2}}\right]$
Magnetic induction	$\mathfrak{B}$	$\left[\mathrm{L^{-\frac{3}{2}}\,M^{\frac{1}{2}}\,K^{-\frac{1}{2}}}\right]$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{\frac{1}{2}}\right]$
Magnetic force	$\mathfrak{H}$	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-2}\,K^{\frac{1}{2}}}\right]$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{-\frac{1}{2}}\right]$
Strength of current at a point	$\mathfrak{C}$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-2}\,K^{\frac{1}{2}}}\right]$	$\left[\mathrm{L^{-\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{-\frac{1}{2}}\right]$
Vector potential	$\mathfrak{A}$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}\,K^{-\frac{1}{2}}}\right]$	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}}\mu^{\frac{1}{2}}\right]$
Capacity	$\frac{e}{\mathrm{E}}=q$	[L K]	$\left[\mathrm{T^2\,L^{-1}}\mu^{-1}\right]$
Coefficient of self-induction	$\frac{p}{c}=\mathrm{L}$	$\left[\mathrm{L^{-1}\,T^2\,K^{-1}}\right]$	[L μ]
Specific inductive capacity	$\frac{\mathfrak{D}}{\mathfrak{E}}=\mathrm{K}$	[K]	$\left[\mathrm{L^{-2}\,T^2}\mu^{-1}\right]$
Magnetic inductive capacity	$\frac{\mathfrak{B}}{\mathfrak{H}}=\mu$	$\left[\mathrm{L^{-2}\,T^2\,K^{-1}}\right]$	μ
Resistance	$\frac{\mathrm{E}}{c}=\mathrm{R}$	$\left[\mathrm{L^{-1}\,T\,K^{-1}}\right]$	$\left[\mathrm{L\,T^{-1}}\mu\right]$
Specific resistance	$\frac{\mathfrak{E}}{\mathfrak{C}}=\mu$	$\left[\mathrm{T\,K^{-1}}\right]$	$\left[\mathrm{L^2\,T^{-1}}\mu\right]$

This table he supp'emented by a second containing certain units in which both electrical and thermal quantities occurred. This table, which is given below, was obtained by means of the following relations :—

Thermo-electric height × temperature = E.M.F.
Specific heat of electricity × (temperature)^2 = E.M.F.
Coefficient of Peltier effect × time = heat.

or $\mathrm{J\,\Pi = E.M.F.}$

Name of Quantity.	Symbol.	Dimensions in Terms of L, M, T, θ and K.	Dimensions in Terms of L, M, T, μ and θ.
Thermoelectric Height	ϕ	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{-\frac{1}{2}}}\theta^{-1}\right]$	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-2}}\mu^{\frac{1}{2}}\theta^{-1}\right]$
Specific Heat of Electricity	k	$\left[\mathrm{L^{\frac{1}{2}}\,M^{\frac{1}{2}}\,T^{-1}\,K^{-\frac{1}{2}}}\theta^{-2}\right]$	$\left[\mathrm{L^{\frac{3}{2}}\,M^{\frac{1}{2}}\,T^{-2}}\mu^{\frac{1}{2}}\theta^{-2}\right]$
Coefficient of Peltier Effect	Π	$\left[\mathrm{L^{-\frac{3}{2}}\,M^{\frac{1}{2}}\,T\,K^{-\frac{1}{2}}}\theta\right]$	$\left[\mathrm{L^{-\frac{1}{2}}\,M^{\frac{1}{2}}}\mu^{\frac{1}{2}}\theta\right]$
Geometrical Capacity	$q'=\frac{q}{\mathrm{K}}$	[L]	[L]

Mr. Blakesley stated that the same difficulty had often occurred to him in connection with the measurement of temperature. He took this opportunity of recording his objection to the term *therm*, which had been recently adopted for the unit of heat. The term was badly derived, for the prefix *therm* was associated with temperature measurements, as, for example, in the words isotherm and thermometer, and not with calorimetric measurements.

Prof. G. C. Foster observed that the subject of the Paper was of great interest and importance, and he hoped that its fuller discussion, after members had had the opportunity of reading Prof. Rücker's Paper in full, would lead to some valuable conclusions.

Prof. S. P. Thompson thought that confusion often occurred from no distinction being drawn between vector and scalar physical quantities. For example, the dimensions of work were given, the same as those of the moment of a force about a point. In the former case, however, a length was multiplied into a length measured in its own direction, while in the latter case a length was multiplied into a length measured at right angles to its direction, and the latter quantity ought therefore to be multiplied by $\sqrt{-1}$.

In connection with this he mentioned a method which he had been accustomed to give to his students of deducing the law that parallel electric currents in the same direction attract each other, from the ordinary law of the inverse square for the repulsion of two magnetic poles. If $m\,m'$ are two similar magnetic poles at a distance r, and the repulsive force f between them be considered positive, we have

$$\frac{m\,m'}{r^2}=f;$$

for the pole m substitute an element of current of corresponding strength, which, as it exerts a force at right angles to its direction, will be represented by $\sqrt{-1}\,ds$, and we have

$$\frac{m\sqrt{-1}\,ds}{r^2}=\sqrt{-1}\,f,$$

and making a similar substitution of $\sqrt{-1}\,ds'$ for m' we have

$$\frac{\sqrt{-1}\,ds\;\sqrt{-1}\,ds'}{r^2}=-f,$$

showing that two parallel currents in the same direction attract each other.

He agreed with Mr. Blakesley in his objection to the term *therm* for the unit of heat, and greatly preferred *calorie*, which had gradually come to be used for the gramme unit of mass instead of the kilogramme, with which it was originally associated.

He stated that ten or twelve years ago Pictet had suggested that temperature might be taken as proportional to the square of the calorific oscillation. He thought it would greatly simplify the idea of specific heat to give up expressing it as a ratio and measure it directly in ergs, since J is merely the specific heat of water in mechanical measure. This would have the effect of eliminating J as a multiplier or divisor in the elementary formulæ of thermodynamics.

Prof. Ayrton observed that the first part of the Paper was of theoretical, and the second part of practical interest. He did not find that students had much difficulty in acquiring accurate ideas of specific heat and temperature, but it was a very different matter in the case of electrical and magnetic quantities.

It was not only students whose ideas of these were confused ; for example, he pointed out that in many standard works, and even in the first report of the British Association Committee on Electrical Units, the velocity v was defined as the ratio of the electrostatic to the electro-magnetic unit of quantity, instead of, as it should be, the reciprocal of this ratio. The misunderstanding arose from a confusion between the units and the numerical measures of the quantities. The simplification of the electrostatic units by the omission of specific inductive capacity was, he thought, most probably due to the fact that Faraday had been under the impression that this constant had the same value for all gases. Boltzmann had shown that this was incorrect, and after the publication of his results the speaker and Prof. Perry had pointed out that the specific inductive capacity of the medium ought to be introduced as a factor into the denominator of the expression for the electrical force between two charged bodies.

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Prof. RÜCKER, in reply to Prof. Thompson's remark about the dimensions of work and moment being identical, stated that he had always explained this by considering the moment as measured by a rotation through the unit angle, the dimensions of the latter being admittedly zero. He pointed out that Baynes, in his "Thermo-Dynamics," had eliminated J from the equations by expressing specific heat in ergs; but this was inconvenient, as specific heats in physical tables were not given in ergs, and in preference to advocating such a change at present he would suggest waiting until we had succeeded in obtaining a scientific scale of temperature.

THE EDMUNDS "DISTRIBUTOR."

During the meeting of the Society of Telegraph Engineers and Electricians last week (which is reported on an earlier page of the present issue) Mr. Edmunds exhibited one of his automatic distributors working in connection with some cells which were feeding about twenty incandescent lamps. No charging current being available the changes had to be made by hand. This was done without the slightest perceptible effect upon the lamp. Mr. Edmunds has given no detailed description of the mechanism of the apparatus, which is of a somewhat complex character, but we take the following admirable description from a recent issue of our contemporary, *Engineering*:—

"The motive power is obtained by a magnet, *s* (Fig. 1), while the intervals between the strokes of the armature are measured by

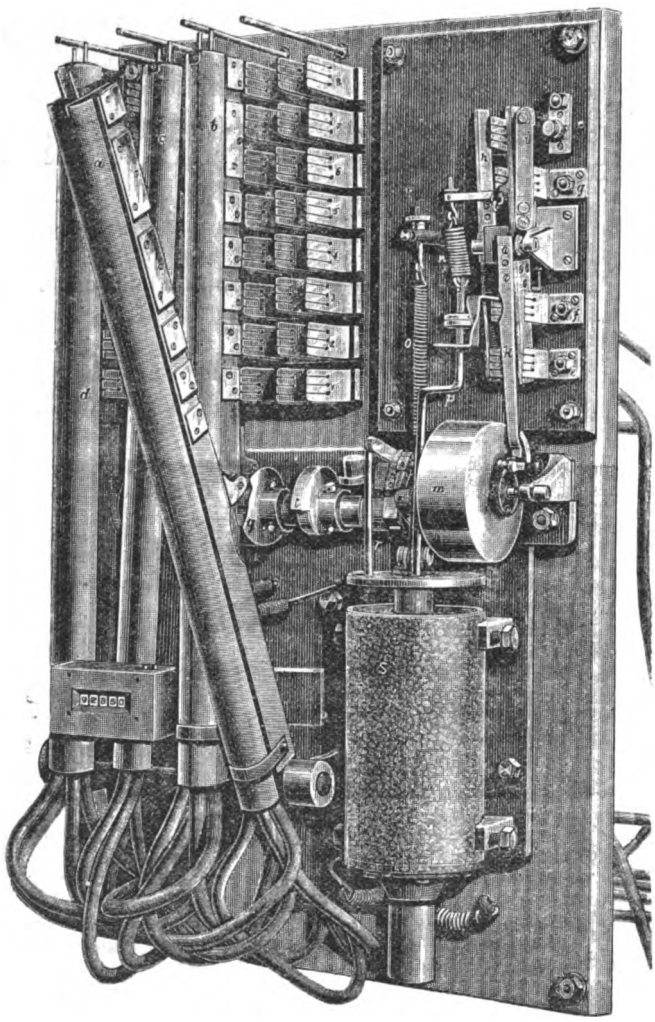

FIG. 1.

the revolving cataract *m* (Figs. 1 and 2). This cataract is a hollow cylinder divided by radial partitions into sections, and partly filled with water. In each section there is a small hole through which the water can leak at a definite speed. On the outside of the cylinder there is a light spiral spring, which is wound up every time the magnet completes a stroke of its armature. This spring then endeavours to rotate the cylinder, but in doing so it has to lift the water which lies in the lower compartments. It is only capable of doing this through a small angle, sufficient to set the water flowing through the leak holes. As this flow continues, the preponderance against the spring decreases, and it is able to rotate the cylinder still further, until finally it completes the entire revolution. When this is done a trigger is released, the magnet makes its stroke, and the entire series of makes and breaks is effected. During the time of charging, the mechanism is at rest except for the slow movement of the cataract cylinder; when this completes its rotation, it gives the order for the change, and then there occurs a moment of activity when all the parts fulfil their functions, to be followed by another period of rest.

"We will now turn to the devices by which the cataract cylinder controls the motive-power magnet—the valve gear, as it were, of the distribution. On the spindle of the cataract is a light disc *l*, with a notch cut into its periphery at one part. On the edge of this disc there runs a roller, carried at the end of a horizontal lever, which is pivoted at its other extremity to the base-board behind. On the upper side of this lever there is a projection or catch which normally stands before the toe of the arm *k*. This arm is connected to a series of rocking switches, with only one of which we have to do at present, viz., *i*, and it has a constant tendency given it to fly outwards, towards the spectator, by a spiral spring, the end of which can be seen to the left of *g*. Now when the notch in the disc *l* comes under the roller above it, the roller and the lever drop; the catch on the latter releases the arm *k*, which flies forward at its lower end, while at the upper end the carbon switch *i* makes contact with a fixed terminal. The effect of this contact is to put the magnet into a shunt circuit from the charging main. The magnet is thus excited and makes its stroke, the speed being modified by a dashpot below, into which the core descends. The descent of the armature effects two operations; it partially rotates the shaft *t*, winding up the spring of the cataract by aid of a pair of toothed wheels, and it then restores the arm *k* and the switch *i* to their former positions as shown in the figure, cutting off the current from the magnet, and permitting the core to be raised by the spring *o*.

"The shaft *t* of the distributor carries a ratchet-wheel, which is turned by a pawl, *v*. This pawl is pivoted to an arm loosely centred on the shaft, and connected by a link, *u*, to the magnet core. There is a catch, worked by the rod *r*, which falls between the ratchet teeth and prevents the shaft being turned too far. Thus, at each stroke of the magnet the shaft is turned a certain definite amount, and it is by this rotation that the various changes of contact are made. There is a third connection, *p*, joining the armature to the spring *n*, which is coupled to a bracket fixed to the arm *k* and moving with it. When the armature descends, this spring is strained, tending to move all the switches connected with the arm *k* into the position shown in Fig. 1. These switches, however, are for the moment locked, and cannot move. But when the magnet stroke is nearly completed, a washer on the rod *p* comes in contact with a trigger arm, and, releasing the switches, allows them to be moved into their normal position, breaking the magnet circuit at *i*, and permitting the spring *o* to again raise the armature. In returning, the toe of the arm *k* raises the roller level, and sets the roller again on the edge of the disc. We have thus traced the governing and motive appliances through an entire cycle; we have seen that the cataract revolves until it releases the arm *k*, the contact *i* is then made, the magnet attracts its armature rotating the shaft and winding up the spring of the cataract, and then the contact *i* is broken and the armature is drawn up.

"We now come to the electrical connections. Each section of the battery is connected by heavily insulated wires to one of the vibrating contact makers *a*, *b*, *c* or *d* (Fig. 1). The contact maker *a* is shown moved back and out of place in order to illustrate more clearly the contact springs 1 to 8. The others are in their proper positions. Each contact maker is drawn towards the base-board by a spring, and is controlled by a cam, *q*, on the main shaft of the distributor. A certain part of the periphery of each cam is cut away, and when this part comes opposite a roller on the contact maker, the latter moves forward between the numbered springs on the board. During the time that charging is going on, the particular section of the battery which is in the charging circuit has its contact maker pressed firmly between the springs, the other three contact makers being held back by the cams. When the charging is suspended the contact maker is forced back, and the adjoining one moved forward, and so on. The successive changes in the charging circuit, which were described in Mr. Edmunds' Paper (*see* last week's *Electrician*, p. 81) are made by the switches at *f* and *g*. The switches at *f* are closed during charging, putting the battery section into the line. When the lever *k* is released the switches at *g* are closed, bringing in the resistance in parallel with that section of the battery. Then *f* is opened cutting out the battery. The magnet immediately makes its stroke, first pushing back the contact maker *a*, and then permitting *b* to go forward. The switch *f* is then closed, putting section B into the charging circuit, and the switch *g* opened cutting out the resistance. It is specially noticeable that the current is never interrupted in either circuit, and consequently there is no sparking at the contacts, and no wear. A spark occurs at *i*,

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due to the self-induction of the magnet coils, but the contacts are here of carbon and always keep clean.

"So long as the cells are not fully charged the distributor continues in action, feeding the sections one at a time. But if this were to continue after the charge was complete the result would be the evolution of gas and a waste of energy. To prevent this there is provided a polarised switch, not shown in the illustration; as long as the electromotive force of the battery does not exceed a given amount this switch remains inoperative, but upon a slight surcharge it connects the two parts of the main directly together, and it maintains the connection till the cells have been sensibly drawn upon. The switch then again comes into action and restores the function of the distributor. Partly owing to this device, and still more owing to the intermittent method of charging which characterises the Edmunds' system, there is no evolution of gas from the cells. The mouths of the containing vessels are filled with a cake or cover of paraffin wax, which stands an eighth of an inch clear of the acid, and has only a small passage through it. There is no foaming or spitting of acid, and no waste to be made up. The intervals of rest which the cells enjoy between each charge seem to have a very beneficial effect upon them, allowing the chemical changes in the plates to complete themselves at leisure.

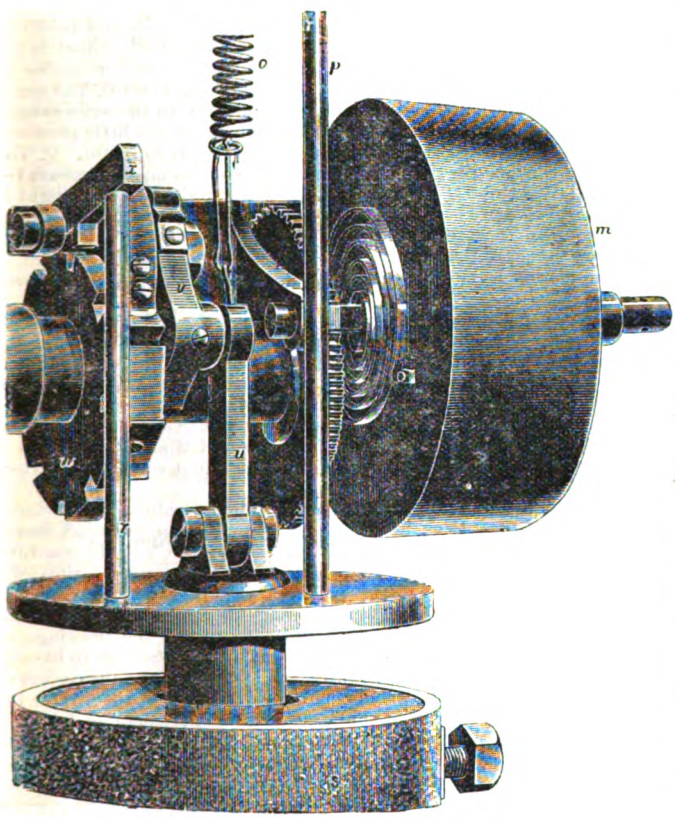

FIG. 2.

"One other mechanical feature remains to be noticed. This is the counter which registers the revolutions of the main shaft. From its indications there can be calculated the amount of electricity the consumer must pay for. The entire system is based on the assumption that the charging current is kept constant; with the usual size of cells it is 70 amperes, and by multiplying this number by the revolutions of the shaft and by the number of minutes of charging which occur during a revolution, a product is obtained expressed in ampere-minutes."

Electroliers.—In his presidential address to the Society of Architects Mr. W. Howard Seth-Smith says:—"Electric lighting has revolutionised the old gasaliers and brackets, and well illustrates the effect of science on art. Great credit is due to the leading manufacturers for the development of beaten copper in the foliated parts; copper is too soft constructionally, but harmonises beautifully with brass. One great principle in all artificial lighting is to have no naked burners, but to diffuse the light through ground glass or silk. Wrought iron, the beauty of which was suddenly appreciated seven or eight years ago, is daily improving in design, more especially under the hands of several excellent firms."

LEGAL INTELLIGENCE.

King, Brown and Co. v. The Anglo-American Brush Electric Light Corporation.

This action came before the Court of Session in Edinburgh on Tuesday. The pursuers are Messrs. King, Brown and Co., of Rosebank Electric Works, Broughton-road, Edinburgh, and the defenders are the Anglo-American Brush Electric Light Corporation (Limited), of York-place, Edinburgh. The action is brought for the reduction of letters patent obtained by the defenders in October, 1878, and other papers for "improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes," material parts of the alleged invention not being new or original. The defenders claim to be the patentees of, and the proprietors of, the alleged invention described in the letters patent referred to, and of the alleged letters patent themselves. The letters patent are dated 18th and sealed 25th October, 1878; the provisional specification was left at the Office of Patents, 18th May, 1878; the final specification was filed 18th November, 1878, the title of the alleged invention being "Improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes." On 10th January, 1882, Sir Henry James, Her Majesty's Attorney-General for England, granted his fiat giving leave to defenders to file a disclaimer and memorandum of alteration of said specification, and thereafter, on 11th January, 1882, the defenders filed the memorandum of alteration and disclaimer dated 8th December, 1881. Thereafter the defenders, on 14th February, 1885, requested leave further to amend said specification, and the Comptroller-General of Patents granted leave so to do, and Her Majesty's Attorney-General for England on appeal affirmed said decision. The pursuers state that the defenders' alleged letters patent, as amended and disclaimed, are invalid, in respect—1. The alleged invention, and, in particular, what is claimed in the 2nd, 3rd and 7th claims, was not, at the date of the alleged letters patent, the subject-matter of a grant of letters patent within the meaning of the Patent Acts. There is no ingenuity or invention displayed in the said invention, and, in particular, claims 2, 3 and 7. 2. The specification, even as amended, was disconform to the provisional specification, and claims an invention different from or not embraced in that disclosed in the provisional specification. 3. There is no sufficient distinction between what was old, or was in use and known at and prior to the date of the said letters patent, and what was new or claimed as new by the said alleged inventor. Further, there are claimed as new, inventions which were old and well known at the date of the said patent. 4. The alleged invention was not new or original. At least material parts of the said alleged invention, and in particular the inventions claimed in claims 2, 3, 4, 5, 6, and 7 of the defenders' specification, disclaimed as aforesaid, were not new or original. The said letters patent, in so far as they relate to commutators and what is now termed compound-winding, were not at the date thereof new or original. The alleged inventor was not the first and true inventor of the alleged invention, described or alleged to be described, in the said letters patent and relative specifications, and it was not first disclosed in Great Britain by him; it was disclosed and was publicly known and used in Great Britain prior to the date of the said letters patents. Inventions similar to or substantially the same with the said alleged invention were described and disclosed in letters patent granted to Alexander Melville Clark, No. 4,311, dated 11th December, 1875, and the relative specifications; in letters patent granted to Samuel Alfred Varley, No. 4,905, dated 19th December, 1876, and the relative specifications; and in a communication to the Royal Society of London on 14th February, 1867, by Charles Wheatstone, F.R.S., "On the Augmentation of the Power of a Magnet by the Reaction thereon of Currents Induced by the Magnet itself," published in the *Proceedings* of the said Society for 1866 and 1867, Vol. XV., page 369; and the same was well known to electricians in Great Britain and used by them. The said alleged invention was also publicly made and used by Siebe and Gorman at their works, 187, Westminster Bridge-road, London, in 1876-77; and by the Electric Engineering Company at their works, Mill-street, Ancoats, Manchester, during the last twenty years. 5. The said alleged invention was not, at the date of said alleged letters patent, of any practical utility. 6. The said specification does not so describe the alleged invention as that a workman of ordinary skill could understand the same, or make or use the alleged invention without further invention. It does not sufficiently disclose the nature of the alleged invention, or how it is to be perfected; in particular, no means of carrying out claim 7, so as to be useful, is shown. 7. By the disclaimers the invention originally claimed is enlarged and extended beyond, and is different from what was described in the provisional specification, or in the original final specification. 8. The specification as amended is not in conformity with the title. The defenders have threatened the pursuers with legal proceedings and liability in respect of the manufacture, use, or sale of the alleged invention said to be covered by the letters patent, and in particular of compound-wound dynamo machines. This, the pursuers state, has very seriously affected their business. The defenders admit having threatened the pursuers with legal proceedings, and that the proceedings threatened were carried out against the Orient Steam Navigation Company, who were using machines made by the pursuers. An action against the Orient Company is pending in the High Court of Justice, England, and, it is stated, the same questions are raised there as in the present action. The pleas in law for the defenders are:—1. The averments of the pursuers are not revelant or sufficient to support the conclusions of the summons; and 2, the averments of the pursuers being unfounded in fact, and their pleas untenable in law, the defenders are entitled to be assoilzied from the conclusions of the summons, with expenses.

Proof in the action was begun on Tuesday. The pursuers were represented by Mr. Graham Murray, Mr. C. S. Dickson, and Mr. Daniel; and

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the defenders by the Dean of Faculty (Mr. William Mackintosh, Q.C.), and Mr. Jameson.

JOHN IMRAY, manufacturing and consulting engineer, was the first witness called for the pursuers. Examined by Mr. Graham Murray, he explained the principles upon which a dynamo electric machine is constructed and the method of its working, with special reference to the methods of winding the field-magnets. In connection with this case he had examined the Hadden and Varley specifications. The former was divided into four divisions. The original patent, in which the provisional specification was stated, gave three divisions—on the construction and use of the armature, the construction of the commutators, and the arrangement of the wires. There was also a fourth division, which was afterwards cut out.

Q. Looking at the provisional specification, how many inventions do you see foreshadowed?—*A.* I can only see one—particulars as to the construction of the commutators with wearing segments attached in a particular way. At the date of the patent in question commutators were old; the construction of the cylindrical form of commutator was also old. The segments shown in the model might have been produced in the old commutators. Turning to the patent as amended, the first claim was for armatures; the second was for a commutator cylinder, the description of which was almost word for word the same as in the provisional specification; the third claim was appropriated to a particular arrangement shown in the drawing; the fourth claim was also for a particular instrument shown in the drawing; the fifth claim was for a commutator having a metallic insular segment attached. Shown a commutator with an insular segment marked "T," witness said he found no hint of that in the provisional specification. It was a perfectly different and distinct apparatus, having different and distinct objects from the object served by making the sub-segments of a commutator detachable. Claim 5 was for a particular commutator, which, instead of making those insular segments entirely insulated, joined them on to the segments of the next brush. There was no hint of that in the provisional specification. In claim 6 there was again the introduction of the insular "T" into the commutator, of which there was no hint in the provisional specification. *Q.* Was there any invention in separating the commutator into two bits and then putting them together with screw nails?—*A.* No. Practically, in the commutator described in the specification there was nothing else whatever but the dividing of it into two bits and then putting it together again with screws.

Witness was shown and described a commutator made in Manchester, and used before the date of the patent. It consisted of two cylindrical segments insulated from each other, and on each there was a semi-cylindrical bit of brass on which the brushes ran. That could be properly described as a commutator in which sub-segments are in proper electrical connection; while there was another exterior segment attached to the sub-segment by a screw or other mechanical device, making a wearing surface. It was, in fact, a combination of sub-segments, wearing segments, and screws. *Q.* Had the incandescent light proved a success at the time of the original specification in 1878?—*A.* No; practically it had not come into use. *Q.* Was the question of the division of the current completely understood, so as to set up lamps in parallel?—*A.* No, because there being no lamps to set up there were no experiments made (laughter). The arc lamps were almost the only ones used at that time. *Q.* Were the arc lights at that time used in series, or just one light to each circuit?—*A.* Almost in every case each lamp had its own dynamo machine to work it. *Q.* Do you find any indication in the Brush specification of the application of this machine for the purposes of electric lighting at all?—*A.* No. In the specification the object stated was to maintain a permanent field for the purpose of electro-plating. The seventh claim was not for a machine so constructed; it was for a combination of helices. At that time two helices upon a magnet were old. *Q.* To a certain extent does self-regulation follow from a permanent field?—*A.* They are not at all identical; but the one follows as a natural consequence of the other. *Q.* Do you find here that Mr. Brush claims a proper shunt as well as a series shunt.?—*A.* Yes.

Q. Supposing a machine to be shunt-wound or series shunt-wound, and to attain thereby a certain power of self-induction, does it necessarily follow that you have got a machine of constant potential?—*A.* No. That would depend upon how the wires were proportioned to the work. In a pure shunt you would never have a constant potential. *Q.* For electro-plating, about which Mr. Brush is talking, was there then any particular necessity for having a constant potential?—*A.* No. *Q.* On the other hand, for electric lighting, as now carried on, there was a great need of constant potential?—*A.* Yes. *Q.* Do you find in Brush's specification the slightest indication, first, of any desire for constant potential and second, of giving the means by which it is secured?—*A.* No, I find no hint of it. From the condition of electric lighting at that period I do not think it is possible that it could have suggested itself, because there was no call for it.

Q. If a machine was made in accordance with the terms of Brush's specification, would it be quite possible to make it and arrange it according to the series-shunt plan of winding and yet make it non-regulating?—*A.* There might be a condition in which it was self-regulated, and there might not. In Mr. Varley's specification for producing electric light, two years before Mr. Brush's, there was described a dynamo machine and an arc lamp. In the final specification it was stated, "Part of the electricity developed by the machine is devoted to maintain the magnetism of soft-iron magnets, and the remaining portion is used to produce the electric light. The method I prefer is to wrap the soft-iron magnets with two insulated iron wires, the one having a larger resistance than the other." That described the series-shunt in every detail. At the time this specification was written it was quite common to use the word electricity as equivalent either to electric current, which was one thing, or electric energy, which was another.

Q. If you read the word "electricity" as "electric energy" is it quite true that part of the electricity developed by the machine is diverted to maintain the magnetism of soft-iron magnets and the remaining portion used to produce the electric light?—*A.* Yes. In maintaining the magnetism of the magnets there is a definite consumption of the electric energy. *Q.* It has been suggested that what Varley described here was not a series-shunt arrangement, but what is called a double shunt?—*A.* I do not agree with that. It would not be consistent with this description in the specification. I cannot conceive any use for a double-shunt arrangement, and if there was a double shunt there would have to be three currents. Varley, he continued, did not give any drawings with his specifications at the time the series-winding and the shunt-winding methods were known. It was quite a simple thing to put the two together. He supposed Varley thought there was no invention in it. He had no doubt that had been done by Varley; it was clearly described at all events. Varley also gave no indication of the different resistances that were to be proportioned to each other; but he stated that the shunt coils would be of greater resistance. *Q.* Do you find anything in Brush's that is not disclosed in Varley's?—*A.* No; the very same words are applied to the description. *Q.* How do you read Brush's claim standing alone?—*A.* I think it is a combination of shunt-helix and of series-helix of electric magnets. *Q.* Do you find any hint of that in the original specification?—*A.* Not of that combination.

Cross-examined by the DEAN OF FACULTY: Mr. Varley made a new invention. *Q.* Was compound-winding not a fresh improvement upon series-winding and shunt-winding?—*A.* At that period there was not much call for it. *Q.* In 1878, whether there was much call for it or not, was it not a distinct improvement?—*A.* Yes, in 1876 and 1878.

Q. So that compound winding was disclosed in Varley?—*A.* Yes. *Q.* And you do not dispute that compound winding was also disclosed and described in Haddan?—*A.* No. *Q.* The question raised was, who invented it?—*A.* There is no question about that (laughter). *Q.* There were series or shunt machines previous to Varley and Haddan?—*A.* Yes. *Q.* The series machine had serious faults.—*A.* It had some faults. *Q.* In the series system when the resistance was increased the machine yielded too little pressure, and, therefore, too little magnetism was produced?—*A.* No doubt. *Q.* The shunt machine, when the resistance was great, gave too much pressure?—*A.* Yes. *Q.* While, on the other hand, when the resistance was slight it gave too little pressure?—*A.* Yes. *Q.* So that both of these machines were unsatisfactory in their resistance?—*A.* Not at that period. The only unsatisfactory part was this, that if you had a series machine and applied it for electro-plating, as soon as your outer circuit was broken you lost your field-circuit.

Q. Is it the case that the compound machine tended to compensate these defects by producing constant potential?—*A.* Yes. *Q.* A shunt series machine tends to reduce constant potential more or less according to the excellence of its proportions?—*A.* No doubt. *Q.* And that was a distinct improvement?—*A.* It has come to be of great importance. *Q.* Do you dispute that Haddan's specification describes a system of compound winding?—*A.* It described a system of compound winding, and also a system of shunt winding. *Q.* And the claim for shunt winding was afterwards disclaimed?—*A.* Yes.

Q. I suppose it described it so that a workman of ordinary skill would, if he followed the directions in R. Haddan's specification, construct necessarily a compound wound machine?—*A.* He could do so, and the machine so constructed would tend to constant potential more or less approximately, according to the proportions used. In Varley's specification there were no drawings, but in Haddan's there were drawings showing the different forms of his compound winding. Witness declined to regard the drawings as throwing any light upon the proportions which the wires were to have to one another. Assuming all to be wire, the wire which was the circuit of high resistance would in breadth be about a third or fourth of the wire in the circuit of low resistance; and in volume, which was the square of breadth, it would be about a ninth. He presumed that the thin wire was longer than the thick one, and no doubt would affect the resistance.

Q. So that, taking the degree of resistance in the one coil and in the other, as indicated by the drawings, would the resistance of the large or series coil be very small in proportion to the resistance of the shunt coil?—*A.* Yes; but as the coil is in connection with the outer circuit, that gave no indication. *Q.* Suppose a workman were to follow the drawing, he would make the shunt coil of very high resistance in proportion to the series coil?—*A.* Yes. *Q.* If a workman not only took the letterpress, but the drawings, and were to construct a machine with the coils having this proportioned resistance would not his machine not only tend to constant potential, but would it not produce a pretty close approximation of constant potential?—*A.* In some particular cases, when you had certain particular circuits, lamps and leads. Continuing, he said that his view was that Varley's specification sufficiently described compound winding, and while there was no claim in his specification applicable to compound winding as so described, his directions of the mode of connecting up his machine produced compound winding. The main object of the specification in certain lines indicated was exactly the same as Haddan's—to keep up a permanent magnetic field. *Q.* "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light." Is that a quite correct description of an ordinary shunt machine?—*A.* It does describe a shunt machine. *Q.* Anybody reading that passage by itself would understand that a shunt machine was meant?—*A.* If he did not know anything else.

Re-examined by Mr. DICKSON: In Haddan's specification there was no suggestion from beginning to end of constant potential, nor was there any definite proportion between the lesser resistance and the greater. In the various figures attached to the specification the proportions were not given. In the letterpress there was no indication of the special circumstances in which constant potential could be obtained, nor was there anything to suggest that that was the end desired. In Varley's specification the simple shunt was clearly not contemplated.

This concluded the evidence of the witness, and the Court rose.

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WEDNESDAY.

The case for the Pursuers was resumed to day before Lord Trayner.

RICHARD MARRIOTT, manager to Millwright and Co., electro-platers and gilders, Birmingham, deposed that in June, 1870, his firm purchased from Henry Wild and Co., Manchester, the commutator produced, and it had been in use ever since. They also purchased commutator rings from Wild and Co. of the pattern produced. There were wearing segments applied to the outside of the commutator, and they had been in use by his firm since 1870.

In cross-examination witness stated that his commutator was identical with the one marked No. 27.

HENRY BOURNE, electro-plater and jeweller, Birmingham, deposed that in 1869 he purchased an electrical machine from Wild, of Manchester. He produced the commutator belonging to that machine. The outside rings were in all cases fastened with screws. He produced another commutator, supplied by the same firm in 1874. The two commutators, Nos. 27 and 28, were identically the same as his, except that thoy had copper rings, or detached segments, while his were of gunmetal. The attachable segments were renewed from time to time.

Cross-examined: The screws in his commutator were fastened from the inside, but that made no difference in the work.

JOSEPH SHILVOCK, pattern-maker and metal worker, in the employment of last witness, said the Wild electrical machine had been in the works as long as he had been there, for seventeen years at least. He identified the commutator produced by his employer as part of the machine.

WM. FREDK. HOBDAY, managing clerk to the Electric Engineering Company, Manchester, produced the journal of Henry Wild and Co. from 1863, showing that they had supplied commutator rings to Mr. Bourne and many others.

ROBERT MARSH, employed in the fitting department of the Electric Engineering Company, Manchester, being shown Nos. 27 and 28 commutators, along with that produced by Mr. Bourne, said they were all in the same form as made by his firm since 1872. The attachable segments were fitted on with screws from the inside, which he considered much better than if fitted from the outside, because, if fitted from the outside, the head would get worn away, and in supplying new rings the screws would have to be drilled out.

Cross-examined.—The one half of the commutator was insulated from the shaft by a vulcanite collar, and the other part was in connection with the shaft.

Dr. JOHN HOPKINSON, F.R.S., examined by Mr. GRAHAM MURRAY, deposed that he had written several Papers in the *Transactions* of the Royal Society on electrical machines. He had directed his attention to Haddan's specification of Brush's patent. *Q.* What is the invention adumbrated in the original provisional specification?—*A.* Simply attaching to the sections of the commutator wearing pieces which can be removed as they wear away. *Q.* Does claim 2 in the complete specification, as explained and amended, correspond with the claim adumbrated in the provisional specification?—*A.* Yes. Claim 3 is a claim for the addition of certain screws for the purpose of attaching the removable segments. The fourth claim is for certain insulated segments "T." The fifth claim is for a particular way of attaching segments "T" to the neighbouring segment. The sixth claim is for the omission of one or two segments "T" from the commutator. *Q.* Do you find anything in the provisional specification that at all indicates the invention which is claimed in claims 4, 5 and 6?—*A.* Nothing whatever. The object of the insulated segment "T" is to ensure equal wear. So far as they are insulated, they are for disconnecting a section of the armature from the commutator. There is no disclosure of that in the provisional specification. Claim 2 is for a commutator cylinder with a hub. At the date of Haddan's patent, in 1878, commutators were old, and in most cases the insulation was a cylindrical hub, to which the segments of the commutator were attached. *Q.* So far as Claim 2 is for a commutator cylinder, in cylindrical form and containing a hub, do you think it possible to read that claim as an invention of a commutator cylinder?—*A.* No. *Q.* In what way do you read claim 2?—*A.* As a claim for attaching wearing segments to sub-segments connected with the wires of the armature.

The DEAN OF FACULTY objected to the two last questions; but the objections were repelled by the Court.

Q. Coming to the portion of Brush's specification which deals with the seventh claim, what was the condition of electrical knowledge and practice in 1878 as regards incandescent lighting.—*A.* The incandescent light was first disclosed as of any practical value at the end of 1879 or early in 1880. *Q.* Until the discovery of the incandescent lamp was there any particular reason or object in having dynamo machines which would maintain a constant potential?—*A.* No, there was no use for such a machine. In Brush's patent there is no indication of a desire to have a machine of constant potential. *Q.* Assume a machine made according to Brush's patent; is it possible that that machine would not have a constant potential?—*A.* It is exceedingly probable. *Q.* What else would you require to have, beyond what is in the specification, in order to have a constant potential?—*A.* You would require to know how large the machine is to be and what speed it is to run, and also the difference in the diameter of the wire. It depends on the proportion of the windings being accurately determined, and that would depend on the speed the machine is to run.

Q. After the discovery of the incandescent lamp, who first began to make constant-potential machines?—*A.* I really do not know, but it must have been about 1881 or 1882. *Q.* What do you find is desired in Brush's specification?—*A.* To maintain the magnetism of the magnets even when the machine was doing little or no external work. He speaks of applying his machine more particularly to electro-plating. Turning to Varley's specification, I find there a disclosure of a certain manner of winding. It discloses a winding of the magnet with two coils, one at the higher and one at the lower distance. The one at the higher distance is constantly in circuit, so that whether external work is being done by the machine or not, electricity would constantly flow through it. The coil at the lower distance shows a series coil for the electric light. *Q.* Does he, according to your view, disclose it in such a way that an ordinary workman could have made a machine?—*A.* Yes; there is no ambiguity about it. *Q.* Does he, any more than Brush, disclose a method of making a machine with a constant potential?—*A.* I do not think either of them had in view at all the desirableness of a constant potential. The light spoken of in the specification is an arc or semi-arc light. *Q.* What part of the specification shows that, when the remaining portion is used to produce the electric light, you are led to believe that that portion also magnetises the magnet?—*A.* He says, "when the electric light has been produced, the greater portion of electricity passes through a circuit of less resistance," which I term the electric-light circuit. It is evident that it is to be a circuit formed of coils upon the machine for the purpose of magnetising the magnets, and that the current produced should afterwards pass through the carbons of the lamp.

Q. It has been suggested that the method which he describes was really a method for separate excitation. Do you take that view?—*A.* No, certainly not. In the specification he has described a particular machine, and he does not tell you how he can wind the magnets of this machine. The method which he has described must, therefore, be applicable to the machine described in the body of the specification. Referring to that machine, I find that he there describes perfectly clearly the way in which the sections of the armature are to be arranged, how they are to be connected together, how connected with the commutator, and how the several segments of the commutator are to be connected with each other. These preclude completely the use of a special portion of that machine for the purpose of exciting the magnetism. The words in the specification also entirely preclude the idea of excitation by a separate machine. So far as series shunt-winding is concerned I find everything disclosed in Varley that is disclosed in Brush. I find in Varley's dynamo machine, No. 29 of productions, that the wires are wound with magnets of different resistance. *Q.* Is that machine one that would be fairly made in accordance with Varley's specification?—*A.* Yes, although there is a little difference in the commutator. [Shown Nos. 37 and 38 of productions.] These are models of a series-shunt or compound-wound machine.

Mr. GRAHAM MURRAY: I shall prove afterwards that the machines of which these are models were made by inexperienced persons, who simply followed Varley's specification.

Cross-examined by the DEAN of FACULTY: *Q.* Your evidence is to the effect that the machine which Haddan describes is substantially the same as that described by Varley?—*A.* In respect of the winding it is. *Q.* I suppose you do not dispute that the series-shunt arrangement was a marked improvement on any previous arrangement?—*A.* It only became a marked improvement by the subsequent discovery of the incandescent lamp. The advantage of it was really this: When the incandescent lamps were introduced it became essential that they should be worked at a definite pressure. By using the series as well as the shunt-winding you were enabled to keep up the pressure. He demurred to the suggestion that it gave the means of accomplishing an important result which did not exist before, as part of Varley's machine did exist before. Haddan described a series-shunt machine sufficiently to enable a workman to construct a series-shunt machine, but he gave no information as to how to make that machine give a constant pressure; and there was a want of scale of the proportions in the diameter and length of the coil, and of definite speed. *Q.* Will any proportion of the winding give substantial constant potential at some particular speed?—*A.* I can hardly say offhand. In many machines, no doubt, any proportion would give you that; but there were no instructions here to meet the case. A workman would reach constant potential by finding it out for himself by experiment. He would not find it out by Brush's patent.

Q. Could you give general directions which would secure constant potential?—*A.* No doubt you could give general directions, but you have to include speed and dimensions. *Q.* Did not Brush actually supply dynamo machines of substantially constant potential as early as 1879?—*A.* I never heard that. *Q.* Do you not know it for a fact?—*A.* Certainly not. Proceeding, he said he was engaged as a witness for Messrs. Crompton in their recent suit with the Brush Company. In his affidavit in the case he did not give all the points of objections to the Brush machine, but he gave sufficient to make out a *primâ facie* case. In 1876 Wheatstone communicated a Paper to the Royal Society "On Shunt Machines." Witness could not say that before that they were known in the market. The knowledge in Wheatstone's communication would reach skilled workmen in time. When Varley spoke in his specification of there being several well-known ways of doing this, he pointed to all classes of dynamo machines known at that time. Any one skilled in this industry would infer from his specification a shunt machine. Compound winding was then unknown as such, and when Varley spoke of preferring another, he meant compound winding. The first three lines of the specification describe shunt, but they did not preclude compound winding. Varley's machine was not a bad machine in its day; but it would be useless in comparison with the machines of to-day. Prior to Brush's patent he had never seen or heard of any compound-wound machines.

Re-examined: A photograph of a rough sketch in a book belonging to Varley would indicate a compound winding.

Mr. SAMUEL VARLEY, the next witness, said that for many years he had devoted attention to electrical machines. In 1852 he joined the Electric International Telegraph Company. From 1861 to 1866 he tried to make a self-exciting dynamo machine, and in the latter year, in conjunction with his father, Cornelius Varley, he managed to make a self-exciting machine, for which he took out a provisional specification. That machine was in the South Kensington Museum and in the Inventions Exhibition. In 1885 he got a gold medal for it as being the first

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self-exciting dynamo. 1876 was the date of his patent in connection with this case. At that time there was no incandescent light. The only light really known was the arc lamp. The specification described among other things a certain method of winding the magnets of a machine. *Q.* According to your view what method of winding is there described?—*A.* What is known as series shunt. He had a machine constructed in accordance with his specification in the works of Siebe and Gorman, of Westminster. It was commenced in 1876 and was finished in the early summer of 1877, and it was used for producing electric light. He had in his possession a private note-book in which he wrote, before the specification was lodged, a description of a series-shunt machine; and a diagram in that book described such a machine. In his specification he said "part of the electricity developed in the machine is devoted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light. There are several well known ways of doing this, but the method I prefer is," &c. The first of these was Wheatstone's plan, and it was known as the shunt machine. There was also Wylde's plan of two commutators, and a certain number of bobbins were used only for exciting the field. In his specification he proceeds to describe the method which he preferred. *Q.* You say you do not claim that in the patent?—*A.* When he was drawing up the complete specification he thought it advisable to consult the *Philosophical Magazine*, in which there were published Papers read by Sir Charles Wheatstone and Dr. Siemens, describing their independent discoveries of the dynamo principle. These Papers were read in February, and there was a Paper read in March by his late brother, C. F. Varley, in which he suggested that the shunt which tended to assist the permanent field-magnets should be wrapped around the field—that was to say, that the electric current should be utilised. It seemed to witness at that time that that left him very little to claim, and he wished to avoid legal differences with his brother. In other words, he came to the conclusion, after consultation with his patent agent, that the description in his brother's patent was of the principle of the series-shunt, with the result that witness did not claim that in his patent. At that time he understood the significance of shunt winding. *Q.* Your specification goes on to describe a certain form of lamp for the maintenance of an arc; was the series-shunt winding necessary or useful for that lamp?—*A.* It was absolutely necessary. It would not have worked with either plain series or plain shunt.

Cross-examined by the DEAN OF FACULTY: Was the machine in Court made by Siebe and Gorman in accordance with his patent?—*A.* The machine in Court was worked at Siebe and Gorman's both experimentally and for a practical purpose. It was worked in order to take a photograph of an ice machine constructed at the works. On that occasion Mr. Siebe, the foreman, and the photographer were present. Witness was not present. Mr. Siebe was now dead, but the foreman and Mr. Gorman were alive, and they were both here. The machine was kept in the works. He was a partner of the firm only as regarded this patent. His connection ended about 1880. He had seen the machine work often. It lay in the works till it was produced in connection with the Crompton case. He never sold a machine made in the terms of his patent; and he never made any machines like it. *Q.* Part of the electricity developed in the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used for the electric light. This is in your specification. Does it apply to a series machine?—*A.* Certainly. *Q.* Then your reading of the word "electricity" in this patent is that it means "electric energy?"—*A.* Certainly; and that is the meaning I apply thoughout, and I did not know any difference between electric energy and electric current. At that time Wheatstone's machines were known, and Gramme's and Wylde's were known in the market, and were sold and worked.

Q. In 1876 was a shunt machine known in the market and worked, or had it merely been described in a Paper before the Royal Society?—*A.* It was commonly known in practice in the British Telegraph Company. I constructed a Gramme machine on the shunt principle. *Q.* Was there any dynamo machine constructed and used on the shunt principle prior to 1876?—*A.* Yes. *Q.* Where?—*A.* In the British Telegraph Company. *Q.* For the purposes of telegraphy?—*A.* For the purpose of separating magnetic iron ore from unmagnetic iron ore. I constructed myself in 1874 a magnetic separator, and I used a Gramme machine as a shunt machine. *Q.* Were there any other machines on the shunt principle which were so used?—*A.* I am inclined to think that the shunt at that time was common knowledge, but of any other shunt machine I am not aware. These machines being well known, he thought he had invented a new machine which was not well known. He regarded compound winding as an important matter; but he did not know the full importance of it at the time. His lamp would not work without it. He did not claim the patent, for the reason he had explained, that his brother had read a Paper describing a mode of working which, witness feared, might be an anticipation. His brother's communication, which was sent to Prof. Stokes and read to the Royal Society in March, 1867, contained the following passage:—"The force expended in the shunt is wasted in heat; but a secondary wire on an electro-magnet or a copper cylinder would very greatly add to the power of maintaining the magnetism and not consume the useless force now wasted on the shunt." [Shown a diagram connected with the Paper.] There was in that a secondary wire in addition to the shunt.

Q. Is there anything in the passage to suggest that the secondary wire was to be excited by a current of electricity passing through it?—*A.* My brother's description gives two alternative suggestions, one a simple copper cylinder, and the other a wire on which the work was performed. The wire drawn on the diagram was the same as a copper tube. He did not claim the patent because he was afraid of being involved in litigation with his brother. He did not abstain from claiming the invention because Gramme or Wylde had anticipated what he described. *Q.* In your specification you describe a machine which was constructed for the purpose of separating the development of magnetic and electric forces. Do you now think it is possible to separate the development of magnetic forces?—*A.* Yes, I do. *Q.* Do you still consider that you thereby greatly increase the magnetic potential in the bobbins?—*A.* Yes. *Q.* Does that greatly increased magnetic potential in the bobbins become at a later stage converted into electricity?—*A.* That becomes converted into electricity. *Q.* Of corresponding high potential?—*A.* I should be doubtful whether I was strictly correct about the energy. *Q.* Was not the whole object of your machine to get an increased amount of energy?—*A.* That was not the sole object. My main object was to get a more perfect machine and get a greater amount of energy, but my theory of reaching that was a mistake. *Q.* Do you still think it possible to use three groups of bobbins, as you propose?—*A.* Yes. *Q.* Did you ever see or hear of a dynamo where there was an odd number of groups of bobbins?—*A.* No, I think not. You took great interest in the recent litigation of the Messrs. Crompton?—*A.* Yes. *Q.* You were very much disappointed when the case came to an end?—*A.* I was. *Q.* I believe you wrote to the solicitors of the company expressing your surprise that they should not have had faith enough to fight the case?—*A.* Yes. *Q.* Upon the Messrs. Crompton declining to fight the case did you ask an interview with Mr. Sellon, vice-chairman of the Brush Company?—*A.* I asked for an interview without prejudice.

Q. In that interview did you propose that if the Brush Company gave you a certain salary you would make it impossible for anyone to challenge your patent?—*A.* No, I did not. *Q.* Did you propose that the Brush Company should take you into their services and give you a salary?—*A.* I stated to Mr. Sellon that my friends had advised me to say that as I had considerable sympathy with the shareholders of the Brush Company, and held a sort of good-will—although I had lost my patent rights—if they offered me an appointment which my friends considered I might honourably accept, I should accept it, and publish an account of what I had done. He received a letter from Mr. Sellon, dated 31st Nov., 1887, stating, "I told you we are unable to recognise in your specification any point which bears upon our right in this matter; but whether this were so or not our acceptance of your candid suggestion that the Brush Company should purchase your silence, and thus, in your opinion, safely secure our royalty by giving you a salaried appointment, is such as could not for a moment be entertained." *Q.* Do you repudiate the construction Mr. Sellon put upon your proposal?—*A.* I do; and in my reply of 15th December I said: "On the advice of some of my friends I sought an interview, and had you seen your way to make any offer, which you did not, and which my friends considered I might honourably entertain, I should have recognised I was selling my birthright for a mess of pottage" (laughter).

Re-examined by Mr. MURRAY.—Mr. Sellon called and wanted to buy witness's machine; but he would not sell it. Mr. MURRAY.—The Brush Company would, no doubt, have kept it in a glass case (laughter). *Q.* Had you known the possibilities of compound winding in electric lighting, would you have run the risk of encountering your brother by taking out a patent? *A.* I am sorry I ever read those Papers.

This concluded the evidence for the day, and the Court rose.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 17th*, 1888.

A decision has just been rendered against the American Bell Telephone Company by the United States Supreme Court, on the question of the right of the Government to institute a suit for the cancellation of patents. This decision is quite unexpected, and as it is the first time that the Courts have gone against the company in a long while, it may not be amiss to rehearse the facts briefly. Some time ago Solicitor-General Jenks, acting as attorney for the Government, brought a suit in equity in the United States Circuit Court of Massachusetts to have the Bell patents cancelled, on the ground that they were obtained by fraud, and that Bell was not the first inventor of the telephone. Against this the American Bell Telephone Company filed a demurrer, in which they asserted broadly, without paying much attention to any other issues, that the United States, in the absence of a specific statute to that effect, had no right to bring a suit to cancel a patent for an invention. Judge Colt, of the Circuit Court, sustained this demurrer, and the matter was brought up on appeal before the United States Supreme Court at Washington, where the decision referred to has now been rendered by Judge Miller. With regard to the contention that the United States cannot bring suit to void the patent, the Court says that such a doctrine is not sound. The United States, in issuing these patents, had bestowed on the patentee rights of immense value, and if the Government, believing fraud to have been exercised to obtain this property, should find it its duty to correct this evil, and to recall these patents, the proper remedy was the one adopted by the Government in this case. As to the contention that it was possible for any individual affected by the monopoly of the patent to set up the defence that the patent was obtained by fraud, and

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that, therefore, the United States should not bring suit, the Court remarked that it was impossible to suppose that the Constitution, in granting the right named to individual litigants, intended to supersede or take away the more enlarged remedy of the Government. The Court decided that the objection of multifariousness of attacking more than one patent at the same time did not have any bearing, as the two patents were issued to the same person, and related to exactly the same subject, while at the present time the Bell Company and Mr. Bell were the only parties to the defence, and their interest in sustaining the patents was the same. On the important ground of objection raised that the Bill of Complaint did not set forth any specific fraud in the securing of the patent, the Court held that the Bill was sufficiently full and explicit on this point. Of course, the Court does not say anything as to the truth of the allegations, but of those allegations themselves it says that they are mentioned with sufficient precision, and that there can be no question that if the Bill be taken as true, there is enough in it to establish the fraud in the procurement of the patents and to justify their cancellation if the Court has the necessary jurisdiction. As I have said, the decision came rather in the nature of a surprise, and telephone stock in Boston fell several points. Yet the question which arises is, what will the Government do with its decision now that it has won it? The litigation is peculiarly the property of the present Democratic Administration, which goes out of office and out of power next March. Even if all the machinery were set briskly in motion now there could be no very great headway made, and it is not to be expected that the incoming Republican Cabinet will care to have anything to do with the scandal other than to let it drop. As the Court said, the charges made against Prof. Bell were sufficient to upset the patent, and, it might be added, were sufficient also to dismiss him for ever from the society of honest men; but then there is nothing new in these charges, and Prof. Bell has already had, at the hands of the Supreme Court, a notable vindication of his character and a striking eulogium on his genius as an inventor. The Court may go back on its own record, but I hardly think it will.

You will remember that in my letter recently I referred to the purchase of the Sawyer-Man property and rights by the Westinghouse Company, and said that this step would involve new relations between the Westinghouse and Thomson-Houston Companies, the latter in its incandescent business having operated largely under the Sawyer-Man patents. It was evident that this change would bring about either a closer affiliation between the two great companies mentioned, or would throw them wider apart. When I inform you that the Westinghouse Company has now purchased the Waterhouse arc system, and that the contract between the Westinghouse and the Thomson-Houston Companies is reported to terminate on the 30th of this month, you will see at once that the two companies have agreed to differ, and that each will stand on its own bottom for electric light business in both departments. In a great many quarters the alliance now terminated was looked upon as the first step towards a wider and stronger combination, and it is evident in that the points at issue were too numerous and important to be reconciled, even in the case of two companies, that the rupture rendered altogether improbable the formation of an union of thirty or forty other conflicting interests. If competition be the life of trade we are likely to see great activity in the electric lighting fields, and in this way no great harm will come from the new conditions. It is understood that the control obtained of the Waterhouse Electric and Manufacturing Company by Mr George Westinghouse, jun., is absolute, the entire capital stock having been bought up. The Waterhouse Company now has about 5,000 lights in operation all over the country. The manufacture will hereafter be carried on at Pittsburg. The reason why the Westinghouse Company has taken up the Waterhouse system is, that the Waterhouse method of regulation, with its third brush, is regarded as the only desirable system of regulating arc lighting apparatus which escapes the patents held by the Thomson-Houston Company and supported by the Courts, with regard to the regulation of the machine by the automatic shifting of the brushes. Mr. Westinghouse seems as thorough in this matter as in others, and having made up his mind to acquire systems which shall cover the whole range of electric light and power, he will doubtless achieve his purpose as quickly as possible. It might appear that the market for electric light apparatus had been pretty well filled up in this country, so that the new business was not worth scrambling for, but we are very far from the point at which our manufacturers must look abroad for new consumers. Even our large cities, which were supposed to have all they wanted a year or two ago, keep ordering new circuits and new lights, and not a few of them are going into the business of running plants for themselves, while this wholesale class of business is supplemented by a mass of small orders which, in the aggregate, yield totals quite as large.

The time is approaching when the authorities will have to do something with regard to the law which requires the execution of capital sentences by electricity after the 1st of January. No action has yet been taken by the State, so far as I am informed, and in the meantime the Medico-Legal Society, of which Mr. Gerry, a member of the Capital Punishment Commission, is also a member, has had a committee at work investigating the subject, and that committee has now made its report. Three methods of application of electricity were proposed. One was the passing of the current from wrist to wrist through the body; another was the passage of the current from a metallic band fastened to the forehead through the body to one of the wrists, and the third method proposed placing the criminal between a metallic cap at his head and a metal plate at his feet. The committee has rejected all these methods. It has made experiments with dogs, and reports in favour of passing the current from the top of the head to a point on the spine between the shoulders. The current will cut every point of vital energy in the brain and the great nerve passages leading downward through the neck, and death will be instantaneous. It is recommended that the electrodes shall be of metal, not over 1in. in diameter, and covered with a thick layer of sponge or chamois skin. The poles and the skin and hair at the point of contact should be thoroughly wet with warm water, and the hair should be cut short. It is recommended that a dynamo generating 3,000 volts E.M.F. should be used, either direct or alternating, the preference being given to the latter. The time of passing the current should not exceed 30 seconds. The Society has not adopted the report, but will take it up at its December meeting.

Patents have just been granted to Mr. Edward Weston on a series of electrical measuring apparatus, upon which he has been at work for some time, and which it is thought by all who have seen the instruments will do great credit to this country, not only for the inventive genius shown in them, but for the fine workmanship brought to bear upon their production. One of the pieces of apparatus is a voltmeter. It embodies the idea that the current to be measured, in circulating over a coil in the circuit, which is supported freely in a uniform magnetic field, shall cause a movement of the coil due to the resultant effect of the current upon the magnetic pole. To the motion of the coil is opposed a uniform resilient resistance, so that the extent of the movement shall be directly proportional to the strength actuating the current, or when the current passes through a high resistance to the E.M.F. of the current. I have no doubt that some of these instruments will soon be seen in England, where I feel confident they will excite admiration.

New York City is about to lose two of its features, which might fairly be spoken of as landmarks. I refer to the two great masts which have stood in Union and Madison-squares for the last six or seven years. These masts reached a height of over 150ft., and carried at the top a crown of six Brush lights. These lights could be seen over the housetops for miles round. Both in winter and summer their rays converted the squares that they illuminated into dainty little fairy lands. In summer time, one of the prettiest sights in the city has been these squares, filled with playing children and well-dressed people lounging on the benches under the leafy trees, through whose waving branches shot insistant gleams of light, brightening the lawns and flowers, and turning the broad walks into pathways of silver. I have never heard anybody speak of the spectacle except with pleasure, and yet it has to be admitted that

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a great many people living or doing business in the neighbourhood complained of the glare of the lights as a nuisance. Anyway, it has been decided that these lofty towers are a failure, and their place has been taken by pole-lights distributed about the square and among the trees, where, to my way of thinking, their effect is greatly diminished by their being shut in by the foliage. Before this the effect of the tower lamps on the square had been that of a soft, subdued moonlight, whereas now all that one gets is a sharp alternation of glare and gloom, so that one is apt, when emerging from the square, to be positively giddy. Taking down these lamps, like putting them up, has been no easy job. The crown of lights, which was daily lowered for recarboning, was quite a massive piece of ironwork, and the pole itself was so heavy that it had to be sawn into three pieces for taking down. I am afraid that we have about seen the last of "high lights" in this city.

Speaking of poles reminds me that the Subway Board also has this subject on its mind. The United States Illuminating Company has succeeded in obtaining a preliminary injunction from one of the Courts restraining the Board from removing its poles and wires, and from doing any acts tending to give the Metropolitan Telephone Company and the Western Union Telegraph Company, or the East River Electric Light Company, any greater facilities or privileges than it grants to the United States Company. The Subway Board were, however, a little too smart for the company, as they had managed the same day to strip off and carry away no fewer than four large cartloads of condemned wires belonging to the company. This fight has to be settled sooner or later, and now that the Board has the sympathy and support of the powers municipal, it is not improbable that the companies in opposition may suffer defeat. It cannot be said that the subways are yet in a satisfactory condition, and evidence of this fact is afforded in the permission granted to the Western Union Company to string four 50-wire cables along Broadway and Park Row until the subways of that neighbourhood are repaired and ready.

On the invitation of General Alexander Webb, President of the College of the City of New York, a meeting of the American Institute of Electrical Engineers was held this week at the College, when a Paper was read by Prof. W. H. Geyer, of the Stevens Institute of Technology, on "The Geyer-Bristol Meter for Direct and Alternating Currents." This meter is based on the principle of the unequal heating of portions of the same circuit having the same sectional area, but differing in shape, so that one presents a greater radiating surface than the other. I have already referred to this invention some time back. M. Abdank-Abakanowicz then read a very interesting little Paper on some theoretical considerations with respect to the Abdank magnetic call, and exhibited his integraph, as well as the Carpentier melotrope and electric recording apparatus for music. Through the kindness of Prof. R. Ogden Doremus, who is well known to many of your readers, the electrical and chemical departments of the college were thrown open to the inspection of the members. I may mention that M. Abdank, who contributed so much to the business of the evening, and who was exceedingly well received, is in this country at present representing the electrical departments of the approaching Paris Exposition. It is understood that he has been very successful, and that the advances made by electricity in America will be illustrated in a series of magnificent exhibits. You may safely count on seeing a good many American electricians on your side of the ocean next year.

An instructive Paper on lightning was read this week before the New York Electric Club by Dr. M. G. Parker, of Lowell, Mass. Dr. Parker, who is an enthusiastic amateur, followed in general the lines of the recent report of the Meteorological Society; but he gave as his own contribution to the study a number of observations tending to prove that the flashes of lightning have a definite rotary motion, turning upon themselves, so to speak, as they go. Some of the motions are twisted, resembling a loosely twisted rope which twists both ways. The curl of motion resembled a twisted ribbon, for example, or a shaving from a carpenter's plane, and was generally from left to right. The Paper was illustrated by some beautiful photographs of lightning.

CORRESPONDENCE.

MR. SPRAGUE ON ELECTRIC MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I note in your edition of last week a reply, by Mr. F. J. Sprague, to my criticism on the Richmond motor curves. Your readers will recollect that in my Paper I published, for the first time I believe, a method of analysing the action of electric motors by means of three variables, the determination of which depended on brake tests. I further showed by curves, taken from different types of machines, the errors likely to result from the use of electrical measurements only.

The Sprague curves I maintained were plotted from calculations based solely on electrical data. The superiority of my method seems so obvious that further discussion is unnecessary; in fact, Mr. Sprague admits the advantages to be gained by the use of brake tests as indicated in my Paper. There are, however, a few misstatements in the reply which I will briefly mention. Mr. Sprague gives three curves referring to one of his stock motors. The first he calls the "Sprague curve." It is presumably calculated from electrical data. The second he calls the "actual curve." I assume this to be obtained by a brake test. The third he calls "Snell's curve." How he obtained the figures of this I know not. The curve, if made according to my method, would show the *actual connection between the variables, speed and current*. If this be correctly plotted from the brake test, then Mr. Sprague's *actual curve* is wrong. Perhaps the experimenter will explain the apparent discrepancy.

Mr. Sprague has further misquoted me with reference to the internal resistance of motors. My figures apply only to the motors, and not to any external resistance.

Perhaps the most interesting point of the reply is that relating to the starting of tram-motors. Mr. Sprague prefers to put the whole of his device in the motor itself. I, for small machines at any rate, would place it outside.

The external resistance may be compared to a *throttle valve*, which wiredraws the electricity, if I may be allowed such an expression. It is not a very efficient arrangement, I grant; but it has two practical advantages. Firstly, it is cheap and easy to keep in order; and, secondly, it spends the superfluous heat where the possible damage is a minimum.

Mr Sprague's device resembles to some extent an *expansion valve*, but the analogy is not very complete. It enables a small current, with many convolutions on the fields, to do the same work per revolution of the armature that a larger current could do with fewer turns. But since the value of the motor electromotive force, and much more so $\frac{\text{B.H.P.}746}{c}$, is much decreased, the speed is proportionately lowered, and with it the efficiency. In fact, I do not think there is much to choose between either method if efficiency be the only criterion. However, the cumulative field device has this serious drawback. To lessen the first rush of current, on making circuit, the ohmic resistance of the motor must be considerable. This implies an extra outlay in the copper for windings. Also, since the total heat waste is confined to the motor, the risk of breakdowns would appear to be increased. In large motors, say 15 or 20 horse-power and upwards, the conditions are somewhat altered. The magnets are usually so massive, and the characteristic so straight, that there is plenty of margin for some cumulative coils up to, say, that point where the characteristic is decidedly flat. The motor should not be expected to work beyond this part of the characteristic, for the efficiency falls so rapidly when this point is passed. I would, therefore, use an external resistance up to the flat part of the curve, and then vary the windings if further regulation were required. This latter arrangement corresponds approximately to the expansion lever and regulator of a steam locomotive, where on starting the lever is put in full gear, and the regulator opened slowly, so as to overcome the inertia of the load without undue shock or strain; then having acquired a certain velocity the lever is notched up to suit the conditions obtaining.

I think that most engineers will admit the justice of my mechanical parallel.

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The figures for shunt motors quoted by Mr. Sprague are decidedly good, and agree well with English practice.

Concluding, I would thank Mr. Sprague for the information he has given us of American motors. I also assure him that English engineers are looking as eagerly as their American cousins for the success of electric traction in the United States, where circumstances have hitherto favoured the enterprise.

Progress reported from across the Atlantic is always welcome, for it means as much solid gain to the whole industry as though it were in London itself. May I venture to hope that Mr. Sprague will shortly favour us with curves of his latest machines, embodying both his and my own method of treatment.—Yours, &c., ALBION T. SNELL.

THE STANDARD CONDUCTIVITY OF COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent "Megohm," in your last week's issue, expresses surprise at 102 per cent. being considered quite an ordinary conductivity for copper.

The lines of this Company, some of which have withstood the storms and smoke of fifteen years, are principally of copper having a conductivity of from 100 to a little over 102 per cent.

A sample of this copper, which I gave to Dr. Muirhead about twelve years ago, caused that gentleman, after testing it, to say that the standard would have to be altered.—Yours, &c.,

F. HIGGINS.

The Exchange Telegraph Company (Limited),
17 and 18, Cornhill, E.C., 23rd November, 1888.

GLOBULAR LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the letter on the above subject in your issue of the 16th inst., the following facts, of which I have had experience, I think would be of interest to your readers.

During a very heavy thunderstorm a very powerful charge entered a cabin and completely destroyed a telegraph instrument there, and in passing to earth (which was taken from the rails) took the form of a very vivid globe of fire, which appeared to be about 18in. in diameter. Part of this same charge travelled the line for 1½ miles, doing slight damage on its way, and went to earth in a very peculiar manner. It fused the binding of the saddle wire, destroyed the roof, split the pole down about 9in., and at this point caught the lightning conductor, which was also used as a "feeder" for the arms, and fused the parts next to the soldered joints (passing over the solder), went on till it came in contact with the stay wires, at which it went to earth. But in passing to earth at this point the charge seemed to be so great that the wire could not contain it. A "sleeper" near which it passed was completely shattered. The great vibrations which were caused by this tumbled several workmen who were near at the time.—Yours, &c., J. H.

Kilmarnock, November 23, 1888.

THE FIRST TELEPHONE CALL OFFICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have observed the correspondence which has been going on in your columns with reference to the date at which the first telephone call office was opened in this country, and as I have been referred to as the authority for a certain date, perhaps I may be allowed to say a word.

The call office at Hall's, the cabman's, in Edinburgh, was not opened by the National Company, but by its predecessor, the Scottish Telephonic Exchange, my connection with which began, I find, in January, 1880. The exact date of the opening of this call office it may not now be easy to discover, but I know that it was shortly after the date I have named. In any case the call office in the Temple, opened, Mr. Munro says, in April, 1880, must have run it hard for priority if it did not precede it.

But however important this question of dates may be as an abstract inquiry, it seems to me that credit belongs not so much to those first in the field as to those who have followed the matter up so as to make call offices of practical utility. Mr. Munro may secure for the United Company the credit of being the pioneers. In precisely the same measure will be their discredit for having abandoned their early policy, for it is well known that at whatever date their call offices were originally opened, they were shortly afterwards closed to the public, and have only within the last few months been reopened as the result of pressure brought to bear upon the directors from outside. The managing director, Mr. Morgan, is even now opposed to their use.—Yours, &c., F. FAITHFULL BEGG.

6, Draper's-gardens, E.C., 26th Nov., 1888.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In thanking Mr. Munro for the information he so kindly gives, I will merely point out that I have sustained my objection to the statement in his article that the first *public* call offices were established in London. He now says that the first public offices were opened there in August, 1881, although a room for the use of the legal fraternity was established in the Temple in 1880. The latter cannot be counted, as it was for the legal profession only, consequently was not *public*. The call offices which I have shown were opened in Edinburgh in 1880 were for *general*, *i.e.*, public use. That they were opened by the Scottish Telephone Company (Limited) does not affect the question. I am not contending for the National Company or any other, but for historic truth.—Yours, &c.,

November 27, 1888. A. S. T. E. and E.

THE DEATH OF M. LUCIEN GAULARD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have the painful duty to inform you of the death of Lucien Gaulard, electrical engineer, who died yesterday at St. Anne Madhouse, broken-hearted, a victim of science and of his own great genius.

I enclose a letter in French, which I have this day sent to the electrical papers here, and I thought that perhaps you would not mind associating yourself and your paper in the expression of universal regret that this sad death must arouse in all generous hearts and all lovers of science.

Whatever can be said, Lucien Gaulard will go to posterity as the first one (to say the least) who invented the practical way of transmitting the electrical current at great distances. Look to every part of the world, the great impetus, the immense projects of central stations of the greatest magnitude. To whom primarily do we owe all this? Lucien Gaulard.

I am sure that the greater portion of your numerous readers, and the great mass of the English nation, always ready to be fair and honour real worth, from wherever it comes and wherever it goes, will associate themselves readily and spontaneously, and share with us French electricians the great loss we have sustained by the death of Lucien Gaulard, and will give his widow this supreme satisfaction in the midst of her grief—that they honour the memory and genius of her departed and unrewarded husband.—Yours, &c., E. H. CADIOT.

Paris, November 27, 1888.

M. Faure's New Secondary Battery.—In M. Faure's new secondary battery the plates are of copper and zinc. The metals are taken in a finely divided state, and are then compressed into plates and enclosed by a diaphragm or septum of prepared asbestos. The electrolyte is a solution of phosphate of potash. During the process of formation the phosphate of potash is decomposed, forming insoluble phosphate of copper on the surface of the copper plate. When the electrolyte is exhausted, a fresh solution of phosphate of potash is put in, and the cell is ready for use. The phosphate of copper is decomposed on discharging, and phosphate of zinc is formed on the zinc plate. On charging the reverse process takes place. The diaphragm consists of sheets of asbestos ·8 millimetres thick. These sheets are dipped into a solution of chloride of calcium or chloride of barium; they are then dried, and afterwards dipped into a solution of soluble silicate, such as the silicate of soda or a fluosilicate, which is capable of forming an insoluble compound with the first salt.

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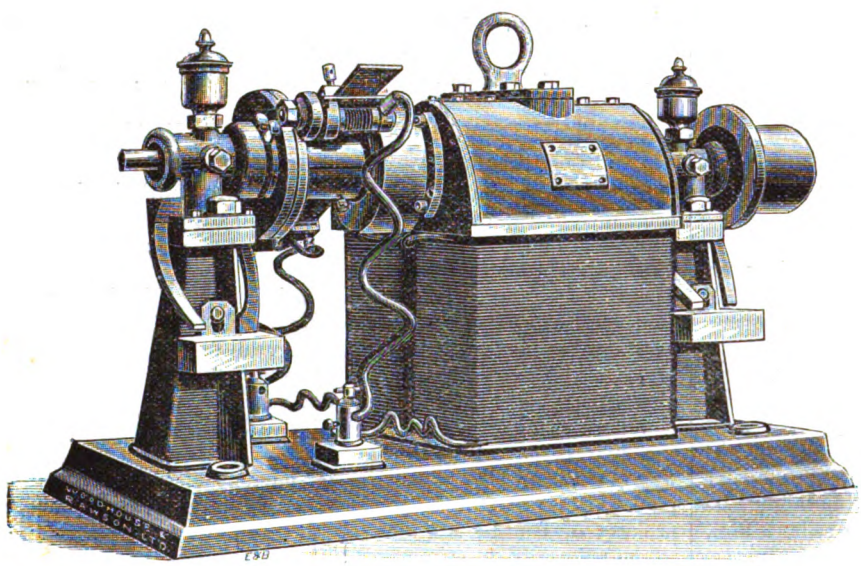
THE WOODHOUSE AND RAWSON DYNAMO.

Our illustration represents the "W and R Dynamo, Type H," which is now being made by Messrs. Woodhouse and Rawson especially for electrolytic work.

It is a substantial and strongly-built machine, having an armature of the shuttle type, and shunt-wound magnets. The makers claim that it is very suitable for use by unskilled persons, as it is not easily damaged by rough handling and requires very little attention. The machine can be wound to any desired voltage between 10 and 200 volts, with an approximately proportional variation in the current output. The following are sizes generally supplied :—

Approx. revs. per min.	Amperes.	Volts.	Watts.
1,500	25	25	625
1,500	12	50	600
2,000	25	40	1,000
2,000	20	50	1,000
2,000	12	80	960
2,000	10	100	1,000

Extreme length over pulley.	Extreme height.	Extreme width.	Diam. of pulley.
2ft. 2½in.	1ft. 4½in.	12½in.	3½in.



The Woodhouse and Rawson Dynamo.

We may mention that Messrs. Woodhouse and Rawson recently supplied twenty-eight of these dynamos on one order from Messrs. Johnson and Sons, of Cross-street, Finsbury, where they are giving every satisfaction.

COMPANIES' MEETINGS.

Crompton and Co. (Limited).

The first ordinary general meeting of the shareholders of this Company was held yesterday (Thursday), at the Cannon-street Hotel, under the presidency of the Right Hon. Viscount Torrington.

The SECRETARY (Mr. Francis Reeves) having read the notice calling the meeting,

The CHAIRMAN stated: Doubtless many of the shareholders were surprised at receiving notice of this meeting so soon after the public issue of the prospectus, but the fact is that the Company was registered on the 30th July last, and, consequently, this meeting had to be convened in compliance with the Act of Parliament. There is no paper of business to lay before the shareholders; indeed, there appears little to be done on these occasions but for the Directors to tell the members anything they may think interesting as to the value of the property they have purchased and the probabilities of its being a successful business. In this case, however, there can be little to add to the statements made in the prospectus, advertised only three weeks ago; but the Directors have been in office long enough to make themselves acquainted fully with the business and to satisfy themselves that the Company have acquired a valuable property. It would be unwise at what is practically a public meeting to give details of the contracts which are in negotiation or of the orders in hand. It may be stated, however, that orders have been taken for a complete installation of electric plant sufficient for 2,000 lights for a Supply Company for one of our provincial towns, also one for a Continental town, and two large installations for docks, besides a quantity of machinery and plant for the Kensington and Knightsbridge Electric Lighting Company, which company have so well served their customers—there having been no failure of the light since they started some two years ago—that they have orders coming in really faster than they can execute them. It is now a well-ascertained and proved fact that electric lighting can be made to pay, and, indeed, to pay well, if only the supply be to a sufficiently large number of consumers, and as a consequence of this knowledge, Electric Supply Companies have been started in many places. Each of these companies will require electrical machinery, fittings, and instruments, some of the orders for which will almost undoubtedly come to this Company. In addition to the employment of electricity for lighting purposes, it is admirably adapted for motive-power. Quite recently an electric crane has been constructed at the works for a firm of large London manufacturers. By means of such cranes, builders will get rid of the necessity of placing a steam engine, as is now done, at the top of high scaffoldingt—he power will in future be generated below and carried up to the crane by means of a small wire. The crane in question has been in successful use for about two months, and gives great satisfaction. Further orders for this class of work are expected. Various other negotiations are in progress for central station lighting, but these are not sufficiently advanced to admit of their being confidently announced to the shareholders. The Directors, however, are hopeful shortly to report something more definite on this subject. The Arc Works at Chelmsford are in good order, and with the few additions now being made to them are sufficiently large and complete to meet the additional orders which the increased working capital is expected to bring. The management of the Company's business is well placed in the hands of Messrs. Crompton and Albright, two gentlemen who owe their position in the electrical world entirely to their professional skill, integrity, and untiring perseverance. They have shown their confidence in the Company by reinvesting £25,000 of their purchase-money in Preference Shares, in addition to their £40,000 of Ordinary Shares, which are paid to them as part of their purchase money. Thus the Company have every security that these gentlemen, who are so very largely interested in the business, will do their utmost to make it successful. The Directors hope to be able to declare an interim dividend in the month of January next, and at the same time propose to pay the interest to those who have paid up in full on their shares. I regret to say that Mr. Crompton has gone to Vienna to arrange some matters with the Imperial Continental Gas Association, and is now in Berlin, where he hopes to make some important arrangements for the benefit of the Company. I have nothing further to add to that statement. If there are any shareholders present who wish to ask any questions in connection with the Company, I shall be very happy to answer them.

The Hon. EVELYN PIERPONT quoted a passage from the prospectus, and asked how the dividends were payable on the Preference and the Ordinary shares.

The SECRETARY replied that after 7 per cent. had been paid to the Preference shareholders, and an amount equal to that amount paid to the Ordinary shareholders, supposing the whole capital were called up and £7,000 were required to pay 7 per cent. on £100,000, then the next £7,000 would be paid to the Ordinary shareholders.

Mr. PIERPONT: Then before the Preference shareholders get anything beyond 7 per cent. those holding Ordinary shares will get about 17 per cent. ?

The SECRETARY: Yes, that is so.

The CHAIRMAN inquired if the point were understood now.

Mr. PIERPONT said that he understood the point now, but he took it from the prospectus to mean that the Ordinary shareholders were to have 7 per cent., and then that the two classes would share alike.

Mr. HODGE asked for some information respecting the subsequent agreement that had been made with respect to the payment of interest to Messrs. Crompton from the date at which the income had been assigned to the Company.

The SECRETARY said that the Company took the benefit of all the profits from the concern from the 31st of March—that was to say, from the date the Company took all the profits. He added that they would be paid their dividend on the amounts paid up, and reckoning from the dates at which they were paid up.

Mr. HODGE thought there was no advantage to the shareholders in having had the profits handed over as from the 31st of March.

The SECRETARY said that there was an undoubted advantage, and that it made the 7 per cent. on the Ordinary shares safe for this year at all events.

Mr. HODGE, continuing, said it was stated in the circular that the income of the Company would be assigned to the new company as from the end of March, but now, owing to this recent arrangement, that had been completely altered, and altered, he maintained, to the prejudice of the shareholders, because, whereas had the first arrangement stood good, the shareholders would have been entitled to a dividend on the shares they held now. Messrs. Crompton would take possession of the sum that had

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accrued, and the shareholders would only have interest on their shares at the rate of 7 per cent., as the instalments were paid up.

The SECRETARY: There has been practically no alteration. The original agreement provided for the payment of interest on the amounts owing to Messrs. R. E. Crompton on the purchase. The amended agreement merely states the date from which that interest is to be paid. As we take all the profits from the 31st March Messrs. Crompton could hardly be expected to give up those profits for three months without some consideration, and we agreed to pay them 5 per cent. on the amounts owed to them. With regard to Mr. Pierpont's question, the Articles of Association were quite clear on the matter of the division of the profits. [He quoted the clause bearing on the subject.]

Mr. PIERPONT thought that the wording of the prospectus was a little ambiguous.

The CHAIRMAN; It is very difficult to word things so that every one can understand them, but the clause which the secretary has read out is very clear.

A vote of thanks was passed to the Chairman and the proceedings terminated.

Filsen-Joel and General Electric Light Company (Limited).

The seventh ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 23rd inst., under the presidency of Sir Rawson W. Rawson, K.C.M.G., C.B.

The SECRETARY (Mr. W. H. Trentham) having read the notice calling the meeting,

The CHAIRMAN said: This is our annual meeting, ladies and gentlemen, and the Directors have thought it a suitable opportunity for bringing before you the state of affairs as they exist at the present moment, with a review of what has taken place during the present year since the important meeting in March last, and we have thought it desirable in our report to invite an expression of your views and wishes as regards the future operations of the Company. We, the Directors, expressed our opinion on the subject last March, but our views did not meet with support, the majority being a sufficiently large body of the shareholders, and my colleagues were reappointed and were instructed to make provision for the sale of the business. I merely briefly review this, which is stated in the report. We did our best to obtain an offer for the business. That offer was brought to your notice, and although it was a small one it was considered under the circumstances that it would be advisable to accept it, and the shareholders did accept it. However, an obstacle was placed in the way of carrying out the sale, and we brought the matter again before the shareholders. One or more of them at that meeting were of opinion that, if a limited time were allowed, an opportunity would present itself of obtaining some satisfactory offer superior to that made by the proposed purchaser. The Directors then determined that they would allow until the general meeting for any shareholders to make such a proposal; and none having presented itself as the time approached for this, our appointed annual meeting, we prepared a report, stating the circumstances, and laying before the shareholders the position in which we were placed. Our recommendation was not approved. The arrangement that we had proposed, in accordance with the express wishes of the shareholders, was not approved, or was stopped and thrown over, and now the time has come for something to be done. We have received two communications from shareholders, one of them being from Mr. Roper, stating that it is his intention at the present meeting to propose steps for the voluntary liquidation of the Company; and the other is from Mr. Fellowes, who comments in detail on the transactions of the past year—which is not exactly the question before us—but who makes no definite proposal. He says it is the Directors' business to make a proposal. But we have done so, and you have not accepted it; we adopted your wishes, and we were not able to carry them out. We gave the shareholder, who thought he could obtain an offer, more than the two months mentioned at the last meeting. But no offer has presented itself, and now, as the Board state in the report, having explained the position, we feel that it rests with the shareholders to furnish an indication of their wishes. It will be my duty to place before you the definite proposal which has been sent in by one of your body. The order of our proceedings, however, is first to move the adoption of this report and accounts, and the first resolution which I now propose is—

"That the report of the Directors, dated the 10th November, 1888, together with the accounts and balance-sheet for the year ended June 30th, be received and adopted."

Mr HORACE W. SCRIVEN seconded the motion.

Mr. GEORGE HOPKINS asked for some further information regarding the accounts, observing that nearly £3,000 worth of Consols and £3,672 had been received in Stocks. The indebtedness of the Company on the 30th of June, as compared with the 30th June, 1887, had increased by £740, making a total of about £7,400; and, looking through the accounts, he was at a loss to see where all that money had gone to. He noticed that £1,307 had been put down as general factory charges, and in looking through former accounts, as far as he could see that was the first time that that item had appeared, and he wished for some explanation of the matter. He really could not understand what they had spent £300 on law charges for. He thought the meeting was held unduly late—five months after the date at which the accounts had been presented—and he wished to know what the general financial position of the Company was at the present time.

The CHAIRMAN stated that they had not expected to hold the meeting at all. The sale of their business had been proposed to be carried out on the 26th July, and they did not proceed to the audit of the accounts until they were forced to do it by the rejection of that sale.

Mr. HOPKINS: But your previous general meeting was in Nov., 1877.

Mr. FELLOWES read a long letter which he had addressed to the Directors on the position, financial and otherwise, of the Company. He dissented from the proposal referred to in the report in writing down the goodwill and patent rights for £25,000 to a nominal amount, holding that, in the hands of good business men, that item might be of even greater value than £25,000, and that the Directors could divide any profit that might be made, whatever the amount of goodwill and patent rights were valued at. He wished to know whether the expenses of the Company could not be materially reduced, arguing that they could be, and holding that it was for the Directors to say whether the Company could be carried on profitably; and if, in their opinion, it could be, then to state the grounds on which it could be. He did not think that a resolution for winding up the Company ought to be proposed before the shareholders had had submitted to them a full statement of the actual position of the Company.

A SHAREHOLDER asked the position of the litigation between Mr. Fyfe, the Company, and Mr. Gwynne.

The CHAIRMAN replied that Mr. Fyfe brought an action during the vacation to restrain the sale to which he (the Chairman) had referred. The Judge thought there was a sufficient ground for placing such an amount of obstacle in the way of carrying it out, or of carrying on the business without it, that it was in the interests of the Company to profit by Mr. Gwynne's willingness to withdraw his offer. The sale having dropped, the Directors knew nothing more except that the Company would have to pay another large bill for costs in the matter of Mr. Fyfe's action.

Mr. QUILTER, M.P., said that he was a large shareholder, and that he represented Mr. Charles Morrison and other large shareholders. He reminded the Directors that ever since he and his friends had been shareholders in the Company they had loyally supported whatever the Directors had brought forward, and that they had abstained from any agitation that had been going on respecting the affairs of the Company. Considering all the circumstances, he and his friends did not intend that the Company should go on as it had gone on, losing money and coming upon the shareholders for fresh funds. They did not believe that the Company could be successfully carried on, and he was sure that there were many shareholders in the Company who could ill afford to support the constant drains which had been made upon them, and apparently for no good purpose whatever. He thought it would be most conducive to the interests of the shareholders that the Company should be wound up, and that they should get out of a very bad bargain, and if it were not decided to liquidate the Company voluntarily, they would take steps to get it wound up forthwith compulsorily.

Mr. SCRIVEN, in answer to Mr. Hopkins, stated that the Directors had not thought it necessary to have another special balance sheet made up to date. Comparing the present with the previous balance sheet, they had called up £3,069 more capital, and they had increased their liabilities by £739. They had also a decrease in cash of £2,063. On that side of the account, therefore, they were £5,861 worse off. But on the other side of the account they had increased the stock, which had been very fairly valued, to the extent of £3,805, and they had increased the book debts by £666. There was a balance loss shown of £734, and there was a dividend paid since the previous balance sheet of £400. That made the figures very nearly balance. The item of £1,307 for general factory charges he was responsible for, it having been his wish to show the shareholders what they might expect the general annual charges to be if it were decided to continue the business. The item had been included in the expenditure previously in another way. Most of the remarks which had fallen from Mr. Fellowes and Mr. Quilter referred to a proposal that would come before the meeting after the adoption of the report. Mr. Fellowes wanted the Directors to make a proposal, but they had done so. Last March they stated that by the expenditure of further capital, and writing down the present capital, a large profit could be made—not from figures that could be shown, but from the future of electricity. He still entertained that opinion, and he believed that if the shareholders worked with the Directors, and the latter had the confidence of the shareholders, now was the time when electricity could be made to pay.

The CHAIRMAN stated that Mr. Fellowes had said that they could divide their profit, notwithstanding the £25,000 standing in the balance-sheet for goodwill and patent rights; but their legal advisers took a different view, and he thought the shareholders would agree that the Directors ought to be guided by the legal advisers of the Company. He then put the resolution, and declared it carried.

On the motion of Mr. SCRIVEN, seconded by Mr. G. L. WHATELEY, Sir Rawson W. Rawson was re-elected a Director of the Company, and the auditors, Messrs. Hays, Akers and Hays, were reappointed on the motion of Mr. HOPKINS, seconded by Mr. QUILTER.

Mr. ROPER stated that the proposal which he wished to make was in accordance with what was set out by the Directors in their report. He believed that they could not continue working, for the reason that "a house divided against itself cannot stand." Therefore, as they had to fall, they had better fall as decently as they could. It was infinitely better that the Company should be wound up voluntarily, as Mr. Quilter had said, for whatever might come back to the shareholders by a voluntary liquidation, if there was a compulsory liquidation they would never see a farthing, and probably they would have to pay up a large amount of the uncalled capital. He therefore proposed—

"That the Directors be requested to take the necessary steps for the voluntary liquidation of the Company."

Mr. QUILTER seconded the motion.

Mr. FELLOWES expressed his opinion that it was not competent for the meeting to pass a resolution winding up the Company, although it might be competent for the Directors to receive an intimation on that matter, in which case a fresh meeting to consider the subject would have to be called.

The CHAIRMAN pointed out that the resolution was not for winding up the Company, but requesting the Directors to take the necessary steps

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with that object, and, of course, the matter would be brought before the shareholders.

Mr. FELLOWES asked whether it was competent for the meeting to consider the question at all.

The SOLICITOR (Mr. Parker) said it was perfectly competent for the meeting to pass the resolution proposed by Mr. Roper. It would then be the duty of the Directors to call another meeting for passing a resolution voluntarily winding up the Company.

Mr. GWYNNE said that he was by far the largest shareholder in the Company, and, under the circumstances, he had come to the same conclusion that Mr. Quilter and that gentleman's friends had come to, that the continuation of the Company in its present divided state was impossible.

Mr. WHATELEY said that the Articles of Association were very stringent, and no business could be brought before a meeting without notice. He therefore suggested that Mr. Roper's resolution should be put as a recommendation to the Directors.

After some further discussion, and the Directors having expressed their views as to the position of the Company, and the best course to be taken under the circumstances, Mr. Whateley's suggestion was acted upon, and the resolution was passed in the form of a recommendation to the Directors.

The CHAIRMAN, in answer to Mr. HOPKINS, pointed out that only £12,000 of the capital remained uncalled, and that the existing contracts were only for one year.

A vote of thanks to the Chairman and Directors brought the proceedings to a close.

Blackpool Electric Tramway Company (Limited).

At the meeting of this Company, held on Saturday last, the following report of the Directors was presented to the shareholders:—

The revenue account shows a balance in hand for the year of £1,834 10s. 9d. Adding to this £22. 19s. 6½d. from last year makes an available amount of £1,857. 10s. 3½d., of which the Directors recommend the following disposal:—

	£	s.	d.
Dividend of 4 per cent. on the paid-up share capital	801	0	0
Depreciation and reserve fund	1,000	0	0
Balance to next year's account	56	10	3½
	£1,857	10	3½

The depreciation and reserve fund, with the addition of £1,000 as above recommended, will be £2,159. The number of passengers carried this year was 711,218, against 618,527 last year. The number of miles run during the year was about 90,000. The retiring directors are Messrs. Horsfall, Bickerstaffe, and Broadbent, who are eligible for re-election. The Board regret to have to record the retirement during the year from the directorate of their esteemed colleague, Mr. Joseph Moseley. Mr. Broadbent's services as Managing Director have been secured again for the coming year.

At this meeting the CHAIRMAN moved the adoption of the statement of accounts and Directors' report. He said: Had they taken less for depreciation, and so made the dividend 5 per cent., there would have been a less dividend next year. The working expenses had been reduced this year something like £500. Last year they were £4,291, this year £3,793. On the other hand the receipts last year were £4,406, this year £5,443, showing that whilst there had been economy in the working, the traffic had so increased that they had now got into a sound position. The machinery was equal to, if not better than, it was a year ago. The line was in good working order, and he thought there was every prospect of a good future. It was also satisfactory to know that although there had been many electric tramways at Brussels, in America, and other places, he believed that there were none, taken altogether, so efficient as the tramway at Blackpool. Working trams by accumulators, electric engines, and other modes, had been tried, but so far the difficulty with them had been the carrying of the dead weight. It might be said this Company had gone to great expense in the formation of its plant, and that was true. No doubt material could be obtained at less cost now, for science and other things had developed of late, but he believed Mr. Smith's electric tramway was the best of anything of the kind in existence at the present time. He then moved the adoption of the report and balance-sheet.

Mr. HOYLE seconded. He mentioned the existence of verdigris upon some of the copper rods, and also thought enough account had not been taken of the property of the metal to contract and expand with the changes in the weather.

The CHAIRMAN explained that as last year only £400 was put to the reserve fund, instead of £700, the amount was made up this year, this being a good season.

The motion was unanimously agreed to.

The retiring Directors, Messrs. Richard Horsfall, John Bickerstaffe and James Broadbent, were then re-elected.

Mr. HOYLE, in seconding the motion for the re-election of the retiring Directors, called attention to the Sunday question. He was informed that if they were to run three months in the year on Sundays in the season they would clear all expenses. He did not see why they should not work on Sundays for three months, nor what harm there was in it.

After some remarks in reply from the Chairman, a vote of thanks brought the meeting to a conclusion.

The Maxim-Weston Electric Company (Limited).

Notice has been given that an extraordinary general meeting of the Maxim-Weston Electric Company (Limited) will be held at the Cannon-street Hotel, in the City of London, on Monday, the 3rd day of December, 1888, at 12 o'clock at noon, when the following resolutions will be submitted as special resolutions:—

1. *That the Maxim-Weston Electric Company (Limited) be wound up voluntarily, and that Mr. John Marks, of 114, Great Russell-street, W.C., Mr. J. M. Klenck, 42, Bishopsgate-street Within, E.C., and Mr. Louis Sealy, of 23, Churchfield-road, Ealing, be and they are hereby appointed liquidators for the purpose of such winding up.*

2. *That the liquidators be and they are hereby authorised to sell and transfer, subject to due provision being made for dissentient shareholders (if any) all the letters patent, business, property, machinery, plant, assets and effects of the company, whatsoever and wheresoever, to a company to be formed with limited liability, under the Companies' Acts, 1862 to 1886, with a capital not exceeding £75,000 divided into 500,000 shares of three shillings each, for the purpose, amongst other things, of taking over and working the property of this company upon the following terms:—(a.) The new company shall pay and discharge the debts and liabilities of this company, and also the expenses of and incident to the winding up of the same, and of the incorporation of the new company, and of the sale and transfer by the liquidators of the assets and liabilities of the company to the new company. (b.) The new company shall allot and issue to the liquidators, or as they shall direct, 312,000 shares in the new company of three shillings each, upon each of which there shall be credited the sum of two shillings, a proper agreement being filed with the Registrar of Joint Stock Companies before the issue of such shares, so that the same may be liable to the payment of one shilling per share and no more.*

3. *That the liquidators be and they are hereby authorised and directed to procure to be allotted to every member of this company requiring the same one share in the new company, with two shillings credited as paid thereon, for and in respect of every share held by him in this company; provided always that, to entitle the members of this company to an allotment of*

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ELECTRICAL MACHINERY.
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such new shares, applications must be made for the same in writing within ten days after the posting of a notice informing him of his right to apply for the same, addressed to his registered address in the books of the company. If no such application is received by the liquidators within the time limited as aforesaid, the right of such members to receive such proportion of shares shall be absolutely at an end, and the liquidators, in order that the necessary capital may be promptly raised, and the liquidation closed, shall dispose of any shares refused or not applied for as aforesaid to any person or persons whether shareholders or not, at such price (if any) and upon such terms as the liquidators may think fit.

4. *That the liquidators be, and they are hereby authorised to continue the business of the company pending the transfer thereof to the new company, and to consent to the registration of the new company by the same or a similar name to that of the company.*

NEW COMPANIES REGISTERED.

MINING AND GENERAL ELECTRIC LAMP COMPANY.—This company has been formed, with a capital of £100,000 in £1 shares, for the purpose of acquiring from the New Portable Electric Lamp and Power Syndicate Company (Limited), their patents and system for the manufacture of an electric miners' lamp, a lamp for the electric lighting of railway carriages, a lamp for domestic purposes, and for use in factories and places where a portable and absolutely safe light is required. The price to be paid for all the patents is £80,000, payable as to £46,000 in cash, £20,000 in fully-paid shares, and the balance, at the option of the directors, in cash or fully-paid shares. Basing a calculation on an estimated annual sale of only 80,000 lamps amongst all the collieries, factories, and railway companies of the United Kingdom (including in this estimate the foreign user of the patents as well), it is stated that a profit of 15 per cent. per annum on the capital of the company would be forthcoming. Three of the directors are Fellows of the Royal Society, and the Earl of Crawford was on the Royal Commission of Mines. Mr. Higson, the consulting engineer, is one of the largest colliery managers, and the managing director of the Ebbw Vale Steel Company.

The company is registered by Paine, Son and Pollock, 14, St. Helens-place, E.C., and the first subscribers are :—

	Shares.
F. H. Sumner, 17, Queen Anne's-gate, Westminster	1
B. Nicholson, The Torrs, South Norwood-park, S.E.	1
J. Wood, 16, Matham-grove, East Dulwich, S.E.	1
H. W. Roach, 33, Warlingham-road, Goose Green, S.E.	1
G. C. Holman, 104, Fort-road, Bermondsey	1
E. W. Francis, 38, Kimberley-road, Clapham-rise, S.W.	1
H. A., 90, Royal-road, Kennington-park, S.E.	1

There shall not be less than three nor more than seven directors of the company. Each director shall hold not less than 500 shares in the company. The directors by way of remuneration for their services shall be paid out of the funds of the company the sum of £2,000 per annum.

SUNGEI UJONG (MALAY PENINSULA) RAILWAY COMPANY (LIMITED). Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, E.C., with a capital of £75,000, in shares of £10 each. Object, to enter into and carry into effect an agreement made between Thomas Heslop Hill and Ambrose Beatty Rathbone of the one part, and the company of the other part, to construct or acquire, and equip, maintain, and work railways, tramways, lines of telegraph and telephones, or other means of communication or appliances of a similar nature in the Malay Peninsula, and for the above purposes to enter into and carry into effect any contracts, and apply for, accept and carry into effect such concessions or authorities as may be deemed necessary or desirable. The first subscribers are :—

	Shares.
W. Marshall, 280, Devonshire-road, S.E.	1
A. Mitchell, 287, City-road, E.C.	1
J. Gates, 61, South-hill-park, Hampstead	1
S. Crouch, 173, Isledon-road, N.	1
E. Disney, Steele-road, Sydenham	1
E. T. Botwright, 23, Sutton-place, Hackney	1
T. Nettleship, 1, Mildmay-park, N.	1

The number of directors shall not be less than three nor more than seven, and the first shall be appointed by the signatories to the Memorandum of Association. The qualification of a director shall be the holding in his own right of shares or debentures or debenture stock in the company of the nominal value of £500. The directors shall be entitled to receive out of the funds of the company by way of remuneration, from the date of the appointment of the first directors, £500 per annum, so long as their number shall not exceed three, and £150 additional for every further director up to five.

WINDSOR AND ETON ELECTRIC LIGHT COMPANY (LIMITED).—Registered by Sydney Morse, 7, Fenchurch-avenue, E.C., with a capital of £30,000, divided into shares of £1 each, 50 being founders' shares. Object, to carry on the business of electric engineers, electricians, engineers and contractors, manufacturers of electrical apparatus, and mechanical and chemical engineers, and of producing light, heat, sound, and power by electricity, galvanism, or magnetism. The first subscribers are :—

	Shares.
Major-General C. E. Webber, 17, Egerton-gardens, S.W.	1
E. S. Churchill, Castlemead, Windsor	1
A. Shipley, Datchet	1
A. W. Shipley, River Bank, Datchet	1
A. Fox, 49, High-street, Windsor	1
W. Sevenoaks, Acre House, Windsor	1
W. J. McCloskie, Peascod-street, Windsor	1

The number of directors shall not be less than three, nor more than seven, and the qualification of a director shall be the holding of at least 20 shares in the capital of the company. The remuneration of directors shall be voted in general meeting.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 23rd, 1888, amounted to £5,842.

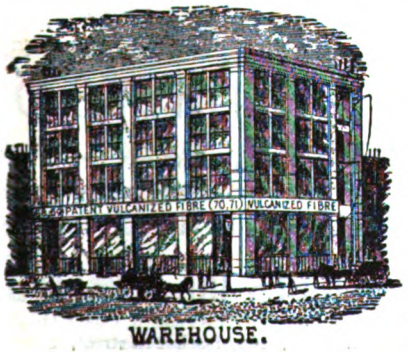
TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—The directors of this company announce that they intend to replace the existing Six per Cent. Debentures, maturing on the 1st January, 1889, with Five per Cent. Debentures, to mature on the 1st January, 1894. Holders of the existing debentures can have them exchanged between the 15th and 31st of December. (Full particulars will be found in our advertisement column.)

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 23rd, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4,938.

FOOTBALL.

PENZANCE V. PORTHCURNOW EXILES.—The advantages gained last year by the Eastern Telegraph Company's Porthcurnow staff (Exiles) over the Penzance Town Club had evidently placed the members of the latter upon their mettle, as the first match this year resulted in a decisive victory for the Town Club. On Wednesday, the 21st inst., the Penzance team journeyed to Porthcurnow to play the return match, and a good game was witnessed. The teams were evenly matched, and a very pleasant game was played, terminating in a win for Porthcurnow by five goals to four. Wind interfered with any long passing, and had it subsided a much faster game would have been witnessed. Teams :—Penzance—Kistler, goal ; Amor and Bodilly, backs ; Hocking, Stewart, and Sampson, half-backs ; Adson (captain), Walton, Baird, Peak, and Runnals, forwards. Porthcurnow Exiles—Martin, goal ; Milward and Hutchinson, backs ; Parker, Evans (captain), and King, half-backs ; Davenport, Roffey, E. Ash, Gordon, and Sweeting, forwards.

THE NON-CONDUCTOR OF ELECTRICITY.



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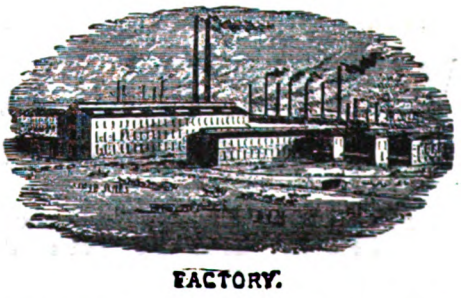
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Nov. 28, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Nov. 28, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	46 47	2 18 6	Jan., Apr., July, Oct.	46¼	45⅜
2,614,820	Stock	15/0	Do. Preferred	77 78	3 10 6	,, ,,	77⅛	76¼
2,614,820	Stock	nil.	Do. Deferred	15¼ 15⅝	...	February	15⅝	15
130,000	£10	5/0	Brazilian Submarine	13 13¼	5 5 8	Mar., June, Oct., Dec.	13⅜	13⅛
16,000	10	9/0	Cuba Submarine	13⅞ 14¼	5 19 9	February and August	...	...
6,000	10	10/0	Do. Preference	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4⅛	3 11 1	March & September	...	...
6,000	5	10/0	Do. Preference	9 10	5 0 0	April and October	9	...
60,710	20	2/0	Direct United States	9⅝ 9¾	4 1 0	Jan., Apr., July, Oct.	...	...
380,000	10	4/6	Eastern	12¼ 12⅜	4 16 0	,, ,,	12⅝	12¼
70,000	10	3/0	Do. 6 per Cent. Preference	14⅞ 15¼	3 19 0	,, ,,	...	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	109¾	...
250,000	10	2/6	Eastern Extension	12⅛ 12⅝	5 2 0	Jan., Apr., July, Oct	13⅝	12¼
22,050	10	8/3	German Union Telegraph and Trust	9 9¼	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅝ 6¾	5 9 1	Jan., Apr., July, Oct.	7	6⅝
178,992	10	3/0	Do. 6 per Cent Preference	14¼ 14⅜	4 2 9	,, ,,	14⅝	14¼
150,000	10	5/0	Great Northern	14¼ 14⅝	5 1 8	Jan., July, and April	14⅝	14 9/16
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
33,348	10	3/0	London Platino Brazilian	7⅛ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6⅝ 7⅛	5 10 4	April and October	...	...
338,225	Stock	13¾%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98¼	98
80,000	10	6/0	West Coast of America	9 9⅛	5 5 3	January and July	9⅜	8⅞
150,000	100	8%	Do. Debentures	121 125	6 8 0	June and December	...	...
88,321	10	1% '78	West India and Panama	1⅜ 2	...	...	1⅜	1⅛
84,563	10	12/0	Do. 1st Preference	12¼ 12⅝	8 12 6	April and October	12½	12¼
4,669	10	*	Do. 5 per Cent. 2nd Preference	12 13	...	...	12½	12 5/8
45,181	15	6/0	Western Brazilian	13¼ 13⅝	5 9 0	March & September	13⅝	12⅝
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	5/16 11/16	5 10 0	Yearly	...	...
220,000	£1	24% '87	Oriental (11s. paid)	3/8 1/2	2 14 11	...	...	...
80,000	5	10/0	United	13½ 14	5 7 2	June and December	14	13⅝
55,000	5	4/6	United River Plate	5½ 5⅝	...	January and July	...	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4 4⅛	...	...	4¼	4 1/16
23,692	5	nil.	Do. (fully paid)	5 5⅛	...	February & August	5 3/16	5
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅛ 2⅜	...	...	2 1/16	2⅛
312,000	½	5% '86	Maxim-Weston	1/16 1/16	...	February	1/16	...
			MISCELLANEOUS.					
37,360	12	36/0	Telegraph Construction and Maintenance	39⅛ 40⅛	6 1 0	March and July	40⅛	39⅝
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17 17⅜	5 14 3	February & August	17¼	17

* No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 551.—Vol. XXII. FRIDAY, DECEMBER 7, 1888. Price 4d.

NOTES.

By a singular coincidence the change of title which the Society of Telegraph-Engineers is about to undergo is attended by a change in the character of the Council almost amounting to an entire exclusion of telegraphic representatives. Whether this feature of the list of candidates just issued by the Society in view of the election next Thursday is the result of accident, or, as our correspondent "Telegraphy" seems to suspect, of design, the incident is to be regretted as giving some colour to the complaints of those who have silently deprecated the disappearance of Telegraphy from the Society's official designation. We hope that these remarks and the publication of our correspondent's letter may, at any rate, have the desired effect on next year's nominations.

The *London Gazette* of this week contains the necessary statutory notices of the various Electric Lighting Companies which intend to apply to the Board of Trade for Provisional Orders under the Electric Lighting Acts of 1882 and 1888. The full list is given on another page. It will be seen that a very large portion of the metropolitan area has been scheduled. The limits extend as far as Hampstead in the North, and Streatham and Greenwich in the South, and may be said to comprise practically the whole of the City, the Central District, and the West End, and most of this area has been covered two or three times over. In a large number of cases the applications will be opposed by the local authorities. It is clear that the Board of Trade has no very easy task before it.

The Chelsea Vestry has declined to endorse the view that an Electric Lighting Order confers any monopoly upon the party to whom it is granted. At their last meeting, after listening to the remonstrances of a deputation from the Chelsea Electric Supply Company, they proceeded to pass resolutions acceding to the requests both of the London Electric Supply Company and of the Cadogan Company to be permitted to lay underground wires within the scheduled districts. The Chelsea Company will no doubt appeal to the Board of Trade, and if an authoritative decision is soon obtained it will not be a matter for regret that this question has assumed an acute form at a comparatively early stage.

At Ipswich another question of not less interest has arisen in connection with the working of the Act. Here, Messrs. Laurence, Paris and Scott, the well-known electrical engineers, have a central station scheme in hand, towards which both the local authorities and the majority of the inhabitants of the town appear to be thoroughly well disposed. Under these circumstances it was hoped that the project could be carried through without legislative sanction. Application was, therefore, recently made to the Town Council for permission to lay underground wires, but, although no opposition was raised, the Town Clerk gave it as his opinion that the Council possessed no authority to give the required permission in the absence of a Provisional Order or a License from the Board of Trade. The matter was, therefore, referred to the Board, in order to ascertain whether their intervention was necessary. At the last sitting of the Council a letter was read from Messrs. Paris and Scott asking permission to erect overhead wires instead; and they also proposed, with the assent of the Council, to apply for a License or Provisional Order. According to a statement in a local journal nineteen-twentieths of the private householders affected had already consented to the erection of overhead wires. It was agreed to refer the question to a sub-committee, but at a later stage of the meeting a telegram arrived from the Board of Trade, in reply to the communication of the Town Clerk, which read as follows:—

> "Question at issue of general regulations, under Section
> "4 of Electric Lighting Act, is still under consideration.
> "Board cannot offer suggestions likely to be of use to
> "Corporation. Think, however, statutory powers should
> "be obtained by License or Provisional Order."

The reading of this telegram seemed to afford considerable amusement to the worthy Councillors, but, on the whole, where local opinion is so nearly unanimous it seems a pity that the undertakers should be saddled with the cost and compelled to submit to the delay of working under the terms of the Act. And in any case we fail to see what responsibility would be incurred by the Town Council if they granted the required permission under the terms of an indemnity agreement with Messrs. Paris and Scott such as these gentlemen would probably be willing to accept.

At the last meeting of the Kensington Vestry, Mr. Lindsay proposed a series of resolutions containing various instructions to the Committee of the Vestry who are charged with electric lighting business. Both these resolutions and the speech in which Mr. Lindsay moved their adoption are of a suggestive character, as will be seen by reference to a later page. Many of the points raised have already been discussed in these

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columns, but there is one remark to which we particularly wish to draw attention. Referring to a proposal that only those companies should be treated with who would consent to a provision for the sale of their works at the end of 21 years. Mr. LINDSAY, from the point of view of the local authority, strongly deprecated such an arrangement. "If companies were willing," he said, "to give up their rights in 21 years, it led to the inference that they were not financially strong, and wished to obtain a concession which would make them stronger, and the Vestry should be especially careful not to give such companies a monopoly." We have already entered a strong protest against any pre-arranged concession of this character, speaking of it as "a gratuitously suicidal act," and we venture to think that this incident proves that our language was not unduly strong. A transfer of the undertaking on fair terms may, of course, be arranged at any time without departing from the spirit of the Act, but what we do most strongly deprecate is that any one Supply Company should endeavour to outbid another by voluntarily consenting to bind themselves to sell at any earlier date than that provided for in the Act.

THE Geyer-Bristol meter, which is described on a later page, presents several features of interest. Everyone will be struck with the ingenuity and simplicity of the idea, and we are inclined to think that it will prove of some considerable practical value, though it is to be expected that the indications will be somewhat sluggish. As an ammeter, at any rate, its advantages are obvious. It is also satisfactory to know that, according to the recent investigations of C. CRANZ, the differences in the heating power of continuous and alternating currents (of the same mean value) are too small to affect the reading of industrial instruments, although, as a matter of fact, the alternating current has a slightly greater effect. This is a result which we venture to think might have been foreseen, since the heat generated when the current wave is at a maximum must take time to reach the surface of the wire, and we imagine therefore that the higher the thermal conductivity of the metal the more nearly identical will be the effects.

REVERTING for a moment to the opinion recently expressed by our contemporary the *Electrical Review*, that it has been finally recognised in this country that the accumulator affords the only feasible method of utilising electric traction, we note that in its last issue our contemporary devotes two columns of editorials to the discussion and dissection of our demurrer. Unfortunately for the value of this controversial effort, the view which we hold, and which we still think to have been set forth with sufficient plainness, is entirely misstated. So far from saying or thinking that battery traction would *only* be possible when an ideal cell has appeared, what we said was that "an ideal cell would furnish an ideal solution," which is a very different thing. In this workaday world we are usually content (more or less) with solutions of all kinds of problems which are very far from "ideal," and it remains for us to strive to approximate as nearly as may be to the standard of unattainable perfection. In the case in point we proceeded to indicate an important step in this direction which, as it seems to us, might easily be taken. Our contemporary having misread the earlier sentence thinks that this suggestion is a mark of "inconsistency!" As to what else our contemporary alleges against us, for our own part we appreciate too well the distinction betwixt "retort courteous" and "countercheck quarrelsome" to be tempted to pursue the discussion further.

A FRENCH electrician has addressed a letter to the Paris Municipal Council containing a highly novel and original suggestion for the lighting of the streets of Paris by electricity, and, at the same time, for effecting a complete reconciliation between all the conflicting interests involved. It seems that this ingenious gentleman has designed a gas engine measuring only 25 centimetres in diameter, and which can therefore easily be placed within a hollow pillar of the size of an ordinary gas lamp. In the same pillar, above or below the engine, he would put a dynamo, and surmount the whole by an arc lamp, and—*voilà tout!*

UNTIL we have taken an opportunity to inspect Mr. RADCLIFFE WARD'S "electric omnibus" we do not care to express a definite opinion upon its merits. It *may* be a feasible idea so long as it is only proposed to run on asphalte roads without serious gradients. But what will the authorities say? Will not the red flag clause come in? Anyhow, we think it is a great deal too bad of the daily papers to insert such solemn foolery on the subject as has been going the rounds this week. After recounting in great detail the route taken in a trial run, the newspapers assure us that "This is the only electrical omnibus in the world *capable of steering to right and left.*" They omit, however, to state that it is also capable of standing still, of turning round, and even of running backwards! Truly this is a marvellous age!

Bedford.—The Bedford authorities have under consideration the lighting of a portion of the borough by electricity. It is proposed to make use of the existing water power.

Telegraphists' School of Science.—The December number of *Science and Art* (the science teachers' organ) contains a biography of Mr. Slingo, the principal of this school.

The Woolwich Ferry Boats.—The new Woolwich ferry boats, "Gordon" and "Duncan," now under construction, are to be fitted with the electric light by Messrs. Laing, Wharton and Down.

Cowpen.—A special meeting of the Cowpen Local Board was held on Thursday, the 21st ult., at which the tender of Messrs. Nicholson and Jennings for lighting the district by electricity was rejected by four votes to two.

Southwark.—At a meeting of the St. Olave's (Southwark) Board of Works on the 27th ult., it was resolved, on the recommendation of the Works Committee, to oppose the proposed license of the London Electric Supply Corporation to erect and maintain electric lines and works, and to supply electricity within the district.

Submarine Telephony.—Buenos Ayres and Montevideo will shortly be connected by a submarine telephone line 50 kilometres in length. The laying of this cable has been undertaken by M. Ocampo, of Buenos Ayres, MM. Mourlon, of Brussels, being the contractors. The Van Rysselberghe system of simultaneous telegraphy and telephony will be used.

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Holborn Board of Works.—At a meeting of the Holborn Board of Works, held on Monday last, a letter was read from the House-to-House Electric Supply Company, asking for the consent of the Board for licenses to produce and distribute electricity in the area of the Board's district. The matter was referred to the Works Committee for consideration and report.

Syra.—A correspondent, writing from Syra, says:—"I do not know whether it will interest you to know that for many years past there has existed here the outer walls of a gasworks, and several attempts have been made by various contractors to come to terms with the municipality for the supply of gas, but hitherto all have proved abortive. The municipality is now very anxious to arrange with some electric light contractors."

The Paris-Brussels Telephone Line.—The Paris-Brussels telephone line, the prime cost of which was covered by the first year's receipts, now yields some £4,800 per annum. It will be remembered that the Van Rysselberghe system is used on this line, and since the line is of phosphor and silicium bronze it gives satisfaction. It is also claimed that much of the success attained is due to the Dejongh telephones which are employed.

Commission of Sewers.—At the last meeting of the Commissioners of Sewers the Clerk submitted a notice from the House-to-House Electric Supply Company of their intention to apply for a license to produce and distribute electricity within the City of London. The subject was referred to the Streets Committee, together with a notice of application for Provisional Order by the London Electric Supply Corporation, to supply electricity within the City of London.

The Phonograph in Telegraphy.—A writer in the *Electrical World* suggests that the phonograph seems to be a promising auxiliary to the Wheatstone automatic system. The phonograph can be substituted for the ink recorder, and the signals read off by a Morse operator at his leisure at lower speed. The phonograph motor would require two different speeds—a high speed for receiving the automatic telegraph signals, and a slow speed for reproducing to the Morse operator.

The Passage of the Suez Canal by Night.—No less than 174 steamers, says the *Bulletin de l'Electricité*, passed through the Suez Canal during the month of September at night-time by aid of the electric light. Of these, 33 had their own apparatus; 63 used plant hired from the firm of Gosse, Worms and Co., of Paris; 52 used English plant hired from MM. Bazin; 17 used English plant hired from the Port Said and Suez Coal Company; the remaining 9 using plant hired from Messrs. Wills and Co.

The Lighting of the City.—On Thursday, the 29th ult., at the meeting of the Court of Common Council, the Chairman of the Commission of Sewers (Mr. W. H. Parnell) stated that everything was now virtually in hand for inviting tenders for the lighting of the city by electricity. The committee had decided the lines on which the contractors would be asked to send in their estimates. Although he could not give the exact dates when they would be invited, he could state that all responsible companies would have an opportunity of tendering.

Accidents with the Electric Light.—Two accidents which occurred quite lately show the necessity for well insulated conductors and the use of some uninflammable material wherever regulating rheostats are employed. In a Belgian theatre a rheostat, which had been carelessly screwed on to some woodwork, managed to set it alight. In another case a *danseuse* happened to lean against a pair of electric light leads; the tinsel on her clothes caused a short circuit, and the current set fire to the dress. The flames were fortunately immediately extinguished and no bodily injury resulted.

A Proposed Submarine Cable between Nicaragua and the West Indies.—According to a Panama journal, a contract has been signed between the Minister of Public Works at Nicaragua and Señor Creus, by which the latter gentleman receives permission to land a cable on the Atlantic coast of Nicaragua. The journal states that the cable will connect the Nicaraguan Republic with the West Indies and New York, and that the Government guarantee that the traffic over the line shall not yield less than $6,000 per annum. Work on the cable has to be commenced within the next three years.

The United Telephone Company.—The new multiple switchboard, which has been in course of erection for some time past at the Westminster Exchange of the United Telephone Company, is now at work. The subscribers' wires were transferred from the old board during the night of the 24th ult., without in any way interfering with the continuous service. The current for ringing the subscribers' bells is obtained from a small generator driven by an engine in the basement of the Westminster Palace Hotel. The board contains the latest improvements, and it is anticipated that the service will be much facilitated by its use.

The Society of Telegraph-Engineers and Electricians.—The annual meeting of this Society will be held next Thursday evening, at eight o'clock, when the election of officers and members of Council for the ensuing year will take place. Sir William Thomson is the new president. The following new names of members are submitted for selection for the Council (three to be elected):—W. Lant Carpenter, Conrad W. Cooke, Sir James N. Douglass, J. E. H. Gordon, and Prof. S. P. Thompson. As Associate Members of Council (three to be elected):—S. L. Branton, Augustus Eden, Sydney Evershed, Guy Carey Fricker, A. C. Curtis Heyward, Captain A. E. Wrottesley, R.E., and Arthur Wright.

The Paris Exhibition.—An Order in Council has been issued applying the provisions of the Patents, Designs, and Trade Marks Act to exhibits at the Paris Exhibition next year. Another Order extends the Act to the East Indian colonies of the Netherlands.—At the meeting of the Executive Council of the British Section of the Paris Exhibition of 1889, held on Friday, the 30th ult., at the Mansion House, Mr. H. Trueman Wood, one of the secretaries of the council, was appointed Commissaire Délégué. Sir Polydore de Keyser, late Lord Mayor, will act as Executive President in Paris as well as in London, the present Lord Mayor, Mr. Alderman Whitehead, being the Honorary President.

Messrs. Gent and Co's Illustrated List of Electro-Medical Apparatus.—Encouraged by the sale of their pamphlet on electric bells and kindred apparatus, Messrs. Gent and Co. have lately issued an illustrated and descriptive list of electro-medical instruments made by them. Judging from the large variety of cautery handles, electrolysis needles, surgical lamps, induction coils, rheostats, switches, &c., which are described, we think the catalogue cannot fail to prove of considerable use in the hands of medical electricians, and the frequent occurrence of such archaic terms as Faradism, Franklinism, faradisation, rheotrope, &c., will probably not lessen its value in this direction. Amongst the exhaustive list of batteries we notice the "Gassner" dry cell, which Messrs. Gent and Co. describe with some reason as the "Perfect Medical Cell."

Electric Sugar.—A telegram from New York reports "the first thorough test, with completed plant, of the electric sugar-refining process." The trial took place at the Electric Sugar Company's works in Hamilton-avenue, Brooklyn. The *modus operandi* was precisely similar to that pursued in the tests with "partial plant," viz., raw sugar at the top of the building became "perfectly snow-white crystallised sugar of the highest quality" when it arrived at the bottom 128 minutes after the commencement of the process. The telegram says, "Old refiners present conceded that the granulation was entirely different from that of common refined sugar. Mr. H. C. Highet, formerly of Liverpool, and now of New York, and Mr. Willett, the leading sugar refiner of New York, expressed great satisfaction at the result." The company announce their intention of starting work early next year, when their patent rights will have been secured.

Messrs. Charlesworth and Co.—We are pleased to note that Messrs. S. Charlesworth and Co., electrical engineers, Richmond Hill Ironworks, Oldham, have been awarded a silver medal for the excellence of their exhibit at the Barcelona Exhibition. We understand this firm have now in hand installations for Messrs. Platt Brothers and Co. (Limited), Hartford Old Works; S. R. Platt, Esq., Werneth (both being complete with steam engines, while the last includes a boiler made by the Oldham Boiler Works Company); repeat orders for over 100 lights

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from the Palm Mill Company (Limited), and also two sets of their portable plant for the night navigation of the Suez Canal for the same firm, for whom the first was made, and which, as we recently noted, passed immediately the company's conditions and trial run. The same firm has also recently completed an installation of over 400 lights for Messrs. J. S. Sykes Brothers, card makers, of Hindley, near Huddersfield.

Valencia Central Lighting Station.—We have frequently drawn attention to the great interest taken in electrical enterprises whether for lighting purposes or for motive power in the town of Valencia. We now have news of the inauguration of an electric light installation there, promoted by the Marquis de Campo. Local electricians believe that it is one of the largest in the world, and the importance of the undertaking may be gathered from the fact that it is said to be capable of illuminating 20,000 lamps, 16 candle-power, a number sufficient to supply the public service, the theatres, and private customers. We understand that the installation has been carried out by Senores Planas y Flaquer of Gerona at a cost of £80,000. We some time ago gave particulars of a large undertaking by which it was proposed to make use of the current of the River Turia for supplying Valencia with motive power and with the electric light. Whether the installation referred to above is a separate undertaking, or is connected in any way with the Turia proposals, is not stated.

Barnet.—At a meeting of the Barnet Local Board, last Tuesday week, a report was presented by the surveyor, giving a list of the electric lamps found out from the 7th to the 16th ult.—numbering in all 13. The chairman (Mr. C. Stevens) reported that the Lighting Committee were going round the district in order to see the effect of the lighting at different points where gas-lamps had been removed and no substitutes provided. The committee had not yet completed their perambulations, and therefore their report was not yet complete. Subsequently a letter was read which had been received from the electric light contractors stating their willingness to supply and fit any additional lamps on the present contract of 16 candle-power at £2. 14s. per annum. They also offered to fit up one 2,000 candle-power arc lamp for the inspection of the Board, without any charge for the experiment. The Clerk said he had seen Mr. Joel since the receipt of the letter, and he was willing to put up a 300 candle-power incandescent lamp free of charge, so that the Board might see the effect of larger lamps, both arc and incandescent.

Coast Defences.—At the Plymouth Chamber of Commerce on the 26th ult., Mr. R. Bayly submitted a motion on the subject of electric coast communication, which he argued should be greatly extended round these islands. Lloyd's had acquired a few signalling stations recently, and he believed the Government had put some twenty coastguard stations in electric connection with each other. But in many respects we were still far behind other countries, notably those whose coasts bordered the Baltic, where telegraph signalling stations were very numerous, and could be used by mariners for ascertaining the state of the weather in the direction they were sailing. Our deficiencies in this respect were conspicuous in such localities as Penarth Roads, Lundy Island, Land's End and the Channel, where vessels are often detained because the Post Office inland system is not connected with the coastguard signalling stations. After some discussion it was decided to send Mr. Bayly and Mr. Bellamy to tender evidence to the Committee on National Defence now sitting in London, and presided over by Lord Hartington.

The People's Palace Technical Schools.—The first distribution of prizes and certificates in connection with the People's Palace Technical Schools took place on Tuesday evening last. Long before the proceedings commenced the Queen's Hall was completely filled by a large and attentive audience. The prizes were given away by the Head Master of Harrow, the Rev. J. E. C. Welldon, who made a short speech, which greatly amused his auditors. After the distribution of prizes, Mr. H. H. S. Cunynghame, Charity Commissioner, spoke at some length on the absolute necessity for technical education in these days of keen competition, and concluded by proposing a vote of thanks to the Rev. J. E. C. Welldon, which was enthusiastically passed. Subsequently a concert was given in the Queen's Hall by the People's Palace Choral Society and the People's Palace orchestra, and a gymnastic display took place in the gymnasium. Excellent results have attended the course of tuition in the Day Technical Schools, the lads undergoing the Science and Art Department examinations in May last with considerable success. The evening classes have proved equally successful; since the present session opened on October 8th, 2,230 students have joined, the average attendance each evening being about 500.

Telegraph Extension in New Zealand.—The *Auckland Press* says that the amount expended by the New Zealand Government on account of telegraph and telephone extensions during last year was £22,984, and the amount proposed to be asked for this year is £20,000, leaving £8,370 for future appropriation. Of the expenditure last year £13,029 was on account of telephone exchanges throughout the colony generally, and was principally for material imported for the purpose. The total capital cost of these exchanges amounted, on March 31st, 1888, to £53,288. The work of the year consisted principally of bringing a large number of small villages into connection with the telegraph system by means of telephones. During last year also a telephone exchange was established at Blenheim. The only important telegraph extension work done during the last year was the erection of the fifth wire on the main north line between Woodville, Tahoraite, and Waipukurae, this being necessary for the proper despatch of the large business on the North Island wires. The further extensions provided for in the estimates of the present year include the erection of a telephone exchange at Greymouth, and also the completion of the Kaipara Heads line, the Middlemarch line, and the line from Waipa to Paru Bay.

Effects of Lightning.—A recent thunderstorm on the West Coast of New Zealand did considerable damage to the telegraph line between Ross and Hokitika. Portions of the wire were melted, and (the lineman reports) "the main body of lightning would then appear to have entered the ground, scooping out a place some 4ft. in diameter, and scattering mud, sticks, and stones, some of which were 10 to 12in. in diameter, in all directions. This, however, does not appear to have exhausted the enormous force, for on the opposite side of the road one would almost think that a ball from a 100-ton gun had been discharged, from the manner in which the scrub, roots, and mud had been sent about, some of it 30 to 50ft. along the road. While this had been going on here as much of the electric discharge as the telegraph wire was capable of conducting had travelled along the wire both ways for about half a mile south and nearly a mile northward, portions making to the earth at nearly every pole in that distance. Some of the poles, of course, have been shattered to pieces and scattered along the road or in the bush, while others have had pieces of various dimensions cut out or split off in the effort of the mysterious force to find the shortest path to the earth. For several chains the telegraph wire has the appearance of being bent at short distances as if it had been wound on a cylinder, having sharp projections at regular intervals."

Bradford Corporation Central Station.—Considerable progress has been made during the last few weeks with the work of erecting the central electric lighting station which has been undertaken by the Corporation of Bradford. Workmen have also been employed for some days in laying the cables along Kirkgate and some of the other thoroughfares in the centre of the town, and it is now believed that the whole of the preparations will be completed before Christmas. A sum of £15,000 has been granted by the Town Council to the Gas Supply Committee to cover the cost of the installation and incidental expenses connected with it. Should, however, the experiment be successful, and the tradesmen and others in the centre of the town show a disposition to avail themselves of the facilities offered them by the Corporation for lighting their premises by electricity, it is probable that the area of supply will be extended. The number of applications which the committee have already received lead them to expect that such an extension will soon become necessary, and, foreseeing this contingency, they are carrying out the present works as though they were

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but a part of a larger scheme, which the Provisional Order obtained for the purpose authorises them to effect. Two main cables are being laid under the roadways from the depôt along Market-street to the Town Hall, and up Darley-street as far as the Free Library, and both these public buildings will be lighted by electricity.

Royal Institution.—At the meeting of the Royal Institution on Monday last, the special thanks of the members were returned for the following donations to the fund for the promotion of experimental research:—Mrs. R. J. Mann (for the late Dr. Mann), £20; Mrs. Bloomfield Moore, £50; Warren de la Rue, Esq., £100. The following are the lecture arrangements before Easter:—Prof. Dewar, six lectures (adapted to a juvenile auditory) on Clouds and Cloudland; Prof. G. J. Romanes, twelve lectures constituting the second part of a course on Before and After Darwin (The Evidences of Organic Evolution and the Theory of Natural Selection); Prof. J. W. Judd, four lectures on The Metamorphoses of Minerals; Dr. Sidney Martin, four lectures on the Poisonous Action of Albuminoid Bodies, including those formed in Digestion; Prof. J. H. Middleton, four lectures on Houses and their Decoration from the Classical to the Mediæval Period; Prof. Ernst Pauer, four lectures on The Characters of the Great Composers and the Characteristics of their Works (with illustrations on the pianoforte); and eight lectures by the Right Hon. Lord Rayleigh on Experimental Optics (Polarisation: the Wave Theory). The Friday evening meetings will begin on January 25th, when a discourse will be given by Prof. G. H. Darwin; succeeding discourses will probably be given by Prof. W. C. M'Intosh, Sir William Thomson, Prof. A. W. Rücker, Mr. Harold Crichton Browne, Prof. Oliver Lodge, Prof. Archibald Geikie, the Rev. Alfred Ainger, the Right Hon. Lord Rayleigh, and other gentlemen.

The Telegraph System of the Argentine Republic.—It would be strange indeed if electric enterprises in the River Plate were not stimulated by the "boom" that has lately been developing in that country. Money has this year been flowing into the country in millions of pounds sterling, the proceeds of loans raised in Europe by the Federal and Provincial Governments. Much of the activity is unfortunately of a speculative character, and may better be described as an inflation; but that there is a considerable increase in the *bonâ fide* trade movement of the country cannot be doubted. A Buenos Ayres paper, referring to the activity of the Postmaster-General, remarks that new offices are being opened daily to facilitate rapid postal and telegraphic communication, and that official is described as indefatigable in having the telegraph lines repaired and, where necessary, reconstructed. In a report to the Minister of Public Works, he states that he has had various sections repaired and reconstructed, amounting in the aggregate to 6,449 kilometres, at a cost of $150,000. He reports that communication in the north of the country, where the network is more complete than elsewhere, has been entirely reorganised and is now quite regular, all interruptions and delays having been done away with. There are at present 4,026 kilometres in course of construction, representing a total outlay of $674,715, and no less than 2,849 kilometres remain to be laid, for which an outlay of $454,630 is required. Congress will be asked to grant the extra expenditure required by the department. It is urged in the interests of the commercial community that every corner of the Republic should be placed in communication with Buenos Ayres; and with Continental financial syndicates ready to lend freely to Argentine borrowers upon almost any pretext, there is little doubt but that this desideratum will be attained. Whether the pace at which Argentines are rushing to pile up debt can be long maintained is another question into which it is not here our province to enquire.

Chelsea Vestry.—At the last meeting the Electric Lighting Committee reported that they had considered a letter from Major Waller, on behalf of the London Electric Supply Corporation, requesting permission to lay an underground cable along Pavilion-road, as shown on an accompanying plan, and the committee recommended that the application be granted subject to the terms of the Chelsea Electric Lighting Order, 1886, being embodied in an agreement between the coporation and the vestry, and during the pleasure of the vestry. With reference to this recommendation, a deputation of four gentlemen representing the Chelsea Electric Supply Company was introduced by General Webber.—General Webber proceeded to ask that the vestry would not approve the recommendation of the Electric Lighting Committee set out above. He did so on the ground that such an introduction by the vestry of competition in the supply of electric light in that part of Chelsea known as District A, for which his company had a provisional order, would be a serious disadvantage to them. The deputation having retired, Mr. Mossop then moved the adoption of the committee's recommendation to grant the application of the London Electric Supply Corporation for permission to lay an underground cable along Pavilion-road during the pleasure of the vestry. He reminded the Board that the Electric Lighting Act was opposed to the establishment of any monopoly. The vestry had also to protect itself from the introduction of overhead wires. They had no power to insist on underground wires, but both the Cadogan Electric Light Company and this London Electric Light Corporation relieved them of the difficulty by volunteering to give undertakings to lay their wires beneath the pavement. The vestry having thus got the power into its hands again should not sanction any monopoly, but only consider the interests of the ratepayers.—The Chairman then put Mr. Mossop's motion to the vote, and it was carried unanimously, the deputation being informed of the decision.—It was also resolved, on recommendation of the committee, that the application of the Cadogan Electric Light Company for permission to lay a 2in. iron pipe beneath the pavement from their works in Manor-street to the Chelsea Embankment be granted, and also that in all future cases in which the pavement is disturbed for the laying of electric wires or cables the vestry relay the pavement at the cost of the company.

Lecture on Electro-Physiology.—On the 6th ult., at Owens College, Manchester, Professor Stirling delivered a lecture on the electrical properties of the tissues, but especially of those composing the nervous system. There are about fifty species of fishes which are known to have specially modified organs for the generation and discharge of electricity. These organs when at rest do not discharge their electricity; but if the animal be irritated electrical shocks are discharged, which in some fishes are very powerful indeed. By means of electrical discharges these animals not only stun their prey, but they ward off the attacks of their enemies. The animal may discharge its batteries voluntarily, but after having done so for a considerable number of times the electrical organs become fatigued, just as muscles after severe exercise are fatigued. At first sight it might seem remarkable that certain animals are provided with structures which evolve powerful discharges of electricity. This, however, is not by any means the most remarkable fact. When we know that the whole of the body of the animal is traversed by the electrical current at the moment it is discharged, it does seem far more wonderful that the tissues of the animal itself are not thereby affected; not even a muscle is caused to contract, although the discharge must necessarily traverse the nervous system as well as the muscles. The animals, therefore, have an immunity from the effects of their own shocks. Darwin admitted that the presence of these organs in a limited number of fishes was a fact not easily explained on the evolution hypothesis. Recent researches, however, have shown that the electrical organs are really modified muscular organs, or the terminations of nervous structures in muscles. This fact greatly simplifies the problem. Muscles and nerve, however, evolve electricity in the living condition; and a variation of the electrical conditions of a muscle, a nerve, or even of protoplasm generally is one of the best signs of the vital activity of these structures. With Galvani's experiments on the twitchings of the limbs of frogs, there commenced the investigation of electrical phenomena, which have led to such splendid results, not only in physiology, but to the development of new means of producing electricity and its numerous applications in the arts. The lecturer demonstrated the classical experiments of Galvani, Volta, Noboli, Du Bois Reymond, and others, showing historically on what lines our present knowledge of animal electricity had been reached.

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LIGHTNING CONDUCTORS.—IV.

BY DR. OLIVER LODGE.

(Continued from page 71.)

Application of Theory to the Last Recorded Experiments.

26. The L loop of the circuit in these last observations consisted of the No. 19 copper wire round the room, and some ordinary connecting wires in addition, the self-induction of which portions may be estimated as about 100 metres. It is fortunately unnecessary to know it exactly, because it is almost lost in the much greater inductance of the No. 19 lead.

Collecting the data required from Article II., and reproducing them here, we have, for the inductance, length, and ordinary resistance of the conductors employed, the following values:—

	Self-Induction L	Length l	Resistance r
	Centimetres.	Centimetres.	Ohms.
No. 19 copper + connections ...	67,000	3,500	3
No. 1 copper	39,000	2,700	·0254
No. 1 iron.....	39,000	2,700	·0881
No. 18 iron	55,000	3,000	3·55
No. 27 iron	63,000	3,000	33·3

The first thing necessary to be calculated is the frequency of vibration; and inasmuch as it is improbable that in any of these cases is the resistance sufficient to make the coefficient m of § 2 comparable in size to n, unless the resistance of the A spark be supposed excessive, I shall proceed to calculate n in the first instance as simply equal to

$$\frac{1}{\sqrt{\{S(L+L_0)\}}}.$$

The electrostatic capacity charged is, the jars, which together equal 28 metres, and the No. 19 lead and connections, which equal four metres more. So the value of S is 3,200 electrostatic units.

When either of the No. 1 leads is the alternative path the total self-induction of the whole circuit is

$$L+L_0 = 67000 + 39000 = 106000 \text{ electro-magnetic units.}$$

Before multiplying these quantities together we must reduce them both to the same units, or, what is better, express both fully and without any convention, as $S = 3200\ K$ centimetres, and $L+L_0 = 106{,}000\ \mu$ centimetres.

So the product

$$\sqrt{\{S(L+L_0)\}} = 18400\ \sqrt{(\mu K)} = \frac{18400 \text{ centimetres}}{3\times10^{10} \text{ centimetres per sec.}}.$$

Hence $$n = 1{\cdot}63 \times 10^6 \text{ per second,}$$

and the frequency, being $\frac{n}{2\pi}$, is in this case just about one quarter of a million complete alternations per second.

A similar calculation for the other leads enables us to fill up the column headed n in the subjoined table.

27. The next thing is to reckon the effective resistance to currents alternating at this rate. The rapidity being so great one may use the simple formula of § 2, which makes the effective resistance the geometric mean between r and $\sqrt{(\frac{1}{2}n\mu l)}$; and hence the next column of the table is calculated, and the column of resistances headed R_0 filled up from it. Unfortunately there is great uncertainty as to the proper value of μ, the magnetic permeability which should be used. Prof. Ewing has found values of μ varying from 60 to 130 or so for hard iron or steel; and all kinds of values for very soft iron up to 2,000, and even, when vibrated, up to 20,000. Now the skin of wires is liable to be hard, and, as they tend to get magnetised by the current in concentric rings, the lower values of μ seem most probable, at least for thin wires. None of the wires were softened or annealed in any way—they were put up as bought at an ironmonger's. It will be well to try a few experiments with some specially selected iron wire. Meanwhile, as I am uncertain what value of μ to employ, I propose to try two very different ones, and see what happens in each case. First I will consider $\mu = 100$, and then $\mu = 2500$.

The quantity $\sqrt{(\frac{1}{2}n\mu l)}$ has the dimension of a resistance, and to bring it to ohms it is divided by 10^9. The value of $n\,L$ can be similarly expressed.

28. The rest is pretty simple. Having filled up the R_0 column as the mean of the preceding and of r, we calculate impedance by reckoning the value of

$$\sqrt{\{R_0^2 + (n\,L_0)^2\}}.$$

For the No. 1 copper wire this comes out 64 ohms.

One estimates the potential V_0, to which the jars were charged, by the length of the A spark, and thus calculates the current amplitude

$$C_1 = \pm\frac{V_0}{n\,(L+L_0)}.$$

The A spark being 2·4 centimetres long, between the knobs of the universal discharger, will be found, by means of the information contained in § 21, to correspond with a length of spark 1·5 centimetres between flat plates. This gives as the initial potential, V_0, 50,000 volts; and accordingly the maximum current comes out 284 amperes for the circuit including the No. 1 copper.

Between positive and negative values of this magnitude, the current oscillates 260,000 times a second until damped out by the exponential term and dissipated into heat. This process does not take long. A column shows the time taken for the current amplitude to decay to one-millionth of its initial value, *i.e.*, 14 times what is ordinarily called the "time constant." The next three columns show the proportion of current amplitude remaining after 1 complete vibration, after 10 vibrations, and after $\frac{1}{4}$ of a vibration.

Near the middle of the table is a column showing the estimated potential available for the B spark, allowing nothing for damping. This is got by simply multiplying the impedance of the alternative path and the current amplitude. Dividing this by 33,000, we get the calculated length of B spark between flat plates; and to obtain from this the corresponding length of spark between the actual micrometer knobs we have to make use of information contained in § 21. These lengths are tabulated in the adjoining column, and to compare with them the experimentally observed numbers are tabulated alongside of those with which they best agree. Considering that the calculation attempts *absolute*, and not merely relative values, the agreement is surprisingly close, for the numbers calculated by means of $\mu = 100$.

29. But then, so far, no allowance for damping has been made. We must next make the supposition that the B spark lags a quarter period behind the A spark, so that the current amplitude has had time to be slightly reduced. The theoretical B spark thus obtained is entered in the last calculated column of the table, and alongside of it the experimental numbers are again quoted, but this time they agree best with the larger value of μ.

As a matter of fact, this lag of a quarter period *must* occur, in order to give time for the current to rise from nothing to its maximum value. The only question is whether the B spark does not lag a little longer, and only occur at the second or third oscillation. If so, of course damping becomes more important; but I see no reason making it probable that if it cannot jump at first it will be able to jump at all. I propose, however, to settle this point by arranging the two sparks A and B alongside of one another, and examining them both in a very rapidly rotating mirror.

30. There is just the possibility that the B spark jumps the gap before the current has had time to be fully excited in the alternative path, and if so, the circumstances regulating its critical value must be different; the hypothesis really requires a fresh theory, in which the electrostatic capacity of the alternative path lead will play an important part. While testing the theory originally suggested in Article I., we must ignore this possibility. Besides, it can be tested experimentally by cutting the wire forming the alternative path at its middle, and seeing whether the length of the B spark is or is not affected. This I have done, the numbers will be given later on;

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Wire round room. Alternative path.	Number of alternations per second multiplied by 2π.	Assumed magnetic permeability of wire, extreme values.		Throttled Resistance of alternative path.	Throttled resistance of whole circuit.	Inertia obstruction in alternative path.	Total Impedance of alternative path.	Amplitude of current. $\frac{V_0}{n(L+L_0)}$	E.M.F. available at B knobs without damping.	Theoretically calculated length of B spark without damping.	Experimentally observed length of B spark.	Damping coefficient $\frac{R+R_0}{2(L+L_0)}$	Total duration of discharging spark.*	Proportion of current amplitude left after one complete vibration. $e^{-\frac{2\pi m}{n}}$	Proportion of charge or of current left after ten complete alternations. $e^{-\frac{20\pi m}{n}}$	Damping ratio for one quarter period. $e^{-\frac{\pi m}{2n}}$	Theoretically calculated B spark with damping.	Experimentally observed B spark.
	Millions per second.	μ	$\frac{1}{2}nl\mu$ ohms.	R_0 ohms.	$R+R_0$ ohms.	nL_0 ohms.	P_0 ohms.	C_1 amperes.	P_0C_1 volts.	centimetres.	centimetres.	m millions per second.	$\frac{14}{n}$ thousandths of a second.				centimetres.	centimetres.
No. 1 Copper	1·63	1	2·2	·75	3·8	64	64	284	18,300	·59	·55	·018	·78	·933	·5	·983	·58	·55
No. 1 Iron...	1.63	100	220	4·4	7·4	64	64	284	18,300	·59	·58	·035	·40	·87	·25	·966	·57	·58
		2,500	5500	22·0	25	64	67·7	284	19,200	·62		·118	·12	·63	·01	·89	·55	
No. 18 Iron.	1·52	100	228	28·4	31·4	83	87·8	267	23,200	·76	·78	·128	·11	·59	·005	·88	·67	
		2,500	5700	142·0	145	83	164·5	267	44,000	1·54		·595	·023	·09	·00000000002	·54	·78	·78
No. 27 Iron.	1·47	100	221	86·1	89	93	126·6	256	32,600	1·07	1·07	·340	·041	·23	·0000005	·70	·75	
		2,500	5525	430·5	434	93	440·0	256	112,000	10·0		1·650	—	—	—	—	—	1·07

* Or time required for the charge to be permanently reduced to one-millionth of its original value.

suffice it to say now that the B spark is immensely lengthened by the change, showing that the wire acts by conduction, not by electrostatic displacement.

31. The column of the table headed "Damping coefficient" gives values of m calculated on the assumption that the resistance of the spark itself is negligible. This may be untrue, but I do not know how to estimate it. If it is more than five or six ohms it ought to be taken into account; though its only effect will be to slightly increase the damping coefficient. Towards the end of the discharge the resistance of the spark may become very large, but by that time the B spark is over.

The last entry in this damping coefficient column, 1·65 million per second, is the value of m for the No. 27 iron wire on the improbable assumption that $\mu = 2500$. This value of m is actually bigger than n, which is only 1·47 million per second, so the whole second approximation breaks down for this case, for it depends on m^2 being moderately small compared with n^2. The column headed n ought indeed, strictly speaking, to be headed $\sqrt{(n^2+m^2)}$; and, knowing this, a more correct value of n can easily be calculated by successive approximations, except for the last line of the table. It is because of this failure to satisfy the second approximation conditions that no further entries are made in the last line of the table. To work out the results of this case the third approximation of § 5 is necessary. The most generally interesting part of the table is included between a pair of double lines.

(To be continued.)

THE WESTINGHOUSE ELECTRIC COMPANY.

The handsome folio volume of some eighty pages, artistically bound, illustrated with excellent wood engravings, and embellished with many decorative designs, which lies before us, purports to be a "circular" from the Westinghouse Electric Company, of Pittsburg. Amongst circulars this publication is probably unique, not so much, however, from its elaborate and artistic get-up as from the fact that it contains an exposition of the results attained by the Westinghouse Company which, whether from their magnitude, their novelty, or their success, must be reckoned among the most marvellous achievements of the present age. In the first *eighteen months* of its existence over one hundred central lighting stations were equipped by the Westinghouse Company, and at the present time—less than two years from its foundation—the company has manufactured and sold the complete outfit for *one hundred and twenty-five* central stations, supplying over 210,000 lamps. Such a record as this could only have resulted from the most favourable combination of what may be called the internal and external conditions. Technical and commercial ability of the highest order, combined with ample capital, unfettered management, and a practically perfect organisation were needed, whilst, above all, the presence was indispensable of that peculiarly Yankee quality of go-aheadness which, to the more sober British mind appears always to verge on the reckless and which yet generally contrives to fall on the right side of the fence. All this would not, however, have sufficed to account for the unprecedented success of the system, but for the fact that in America the field was already white unto the harvest. Low-tension distribution had practically arrived almost at the end of its tether, and the country, already familiar with the advantages of electricity, was prepared to welcome with open arms a system of which the advantages were so transparent. The cheap and rapid manner in which the conductors could be placed was doubtless sufficient by itself in many cases to ensure its adoption.

The American mind does not wait "till somebody else has tried it first," and the fact that a system is in the earliest stage of practice seems generally to be an additional recommendation. The result is that already, and for some time past, the company keeps a wholesale stock of complete central station outfits, so that on receiving an order the entire plant can usually be forwarded within twenty-four hours!

In proceeding to note some of the points in this manifesto which are of chief interest to the English reader, it should be

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stated at the outset that the "circular" is by no means written with a view to furnishing technical details; on the contrary, these are sometimes avoided with marked care. The object in view is definite and practical, namely, to demonstrate to the world at large the superiority (from the Westinghouse point of view) of the alternate over the continuous current in point of economy, efficiency, simplicity, and flexibility, and, incidentally, no doubt, to show also that their own system in particular combines all these advantages in a special degree. It must, however, be remembered that the comparison is made from the American standpoint, and, therefore, almost solely with the Edison or other low-tension systems, and not with the methods of battery transformation which are now somewhat in vogue with us.

On the opening page, in a general comparison of the alternating with the continuous current systems of distribution, we are told that the former "involves far less complication of parts by retiring altogether a long list of commutating, regulating, and distributing devices, now known to be entirely unnecessary." This is a claim which, though it would be hard to gainsay, has not, we think, been fully realised by the advocates of alternate current distribution in this country. The supposed difficulty of regulation and of running alternators in parallel has again and again been alleged as a serious objection. At the same time the truth of the assertion receives confirmation from the practice at the Grosvenor Gallery, where the method of regulation is reduced to the utmost limit of simplicity.* As to parallel running, neither the Westinghouse nor the London Electric Supply Corporation find it necessary to the working of their systems, though we still venture to believe that this method will, in many cases, prove to be both practicable and advantageous.

The next point to which we may refer is that of lamp voltage, in which there is a marked difference betwixt English and American practice. The Westinghouse Company has adopted 50 volts as the standard for their secondary circuits. Now, although we have several times taken occasion to recommend the adoption of the same figure in this country, yet we have done so for reasons of a different character from those which appear to prevail in America. We read with some surprise that "all manufacturers would be glad to use a lamp of as low resistance as possible for the sake of efficiency," and again, "a high-resistance lamp is inherently a low-efficiency lamp." If the term efficiency is employed in the usual sense, we can only suppose that this points to some inherent peculiarity in lamps of American make—at any rate, we have yet to learn that this consideration applies to the lamps made in England. The strong reason which we discover in favour of the 50-volt lamp is, that it is more easy to manufacture such lamps in large quantities to a uniform standard, and therefore its general use would directly facilitate that substantial reduction in the price of lamps which is so much to be desired. We think also that there can be no doubt that these lamps have a somewhat longer life. Of course the matter is to some extent in the hands of the lamp makers, who might easily reduce the price of lamps of lower voltage; but then again, so long as people will pay for an inferior lamp, they may not think it to their advantage to foster the use of lamps of greater durability. If so, we think their policy a mistaken one. The lamps made by the Westinghouse Company (under the Sawyer-Man patents) are of 10, 16, 20, 25, 32, 50, 75, 100 and 150 candle-power, and all of 50, 75, or 100 volts. The two largest sizes have each two filaments in parallel. The 50 and 75 candle-power lamps are strongly recommended by the company for the lighting of retail shops.

Great stress is laid upon the fact that the difficulty of calculating the proper size of the mains in the low-tension system practically disappears under the high E.M.F. which is used with the alternating current. If the initial difficulty were the only thing to be considered this would be of less importance, but the serious nature of the objection arises from the fact that an extensive addition or alteration to the number of lamps may at any time upset the whole of the arrangements, and necessitate a serious expenditure of time and money.†

* See *Electrician*, November 9, 1888.

† In a Paper on "Central Station Lighting in Germany," which appears elsewhere in this issue, will be found an interesting account of the "model" system of determining the size of mains for low-tension distribution.

Although all Westinghouse dynamos are built for a uniform potential difference of 1,000 volts, yet in practice they do not restrict themselves to this limit for the primary circuits. If any circuit is of specially great length it is fed from a converter placed in the central station, by means of which the potential is raised to any required extent. Thus, one dynamo is sometimes employed to feed two or more circuits at different potentials. The circular justly remarks that this affords a beautiful illustration of the flexibility of the system. It is possible that the capabilities of the Westinghouse high-speed engine have had something to do with determining the limit of output, but at present only four sizes of machines are constructed; these are for 500, 750, 1,500, and 3,000 lights respectively. We may remark that the pulleys of these machines are made of compressed strawboard, which is said to have been found by experience to excel other material for belt traction.

The design of the Westinghouse converter has already been described in our columns,* and need not be repeated. But we may mention that the excellence of the design seems to be proved by the following statement:—"In our laboratory experiments we have repeatedly overloaded converters until the insulation was entirely burned off, leaving the coils bare, and have found that it was, even under these circumstances, impossible to force the primary current on to the secondary circuit. *In short, it is essentially impossible for the primary current to pass the converter and enter the building, nor do we believe that there has ever occurred or ever can occur an instance of this nature.*" The experiment, however, was probably made with only 1,000 volts on the primary. It would be interesting to know whether the same result would be attained with a converter built for, say, 2,500 volts, and in any case we should be rather slow to endorse this view to its full extent. All Westinghouse converters are enclosed in air-tight casings of cast iron, and they have been placed in every conceivable situation within or without the buildings to be lighted. The largest size at present made furnishes a secondary current of 40 amperes. The practice of coupling the secondary circuits of several buildings in parallel and feeding them from one group of converters is not recommended, though it is occasionally resorted to. On special circuits of 2,000 or 3,000 volts two or more converters of the ordinary type are used with the primaries joined in series. Full advantage is taken of the properties of the alternating-current in the matter of regulation by impedance coils with a trifling expenditure of energy. We expect to see this feature largely resorted to in the alternating-current systems which are now being developed in this country. For domestic installations a "house regulator" is provided, which can be set to give any one of seven different voltages on the lamp circuit. This, however, is not a mere impedance coil arrangement, since on a 50-volt circuit the following successive steps may be taken—25, 30, 37½, 45, 50, 52½, and 55 volts. Thus it will be seen that the regulator enables the consumer to burn his lamps *above* the normal voltage whenever extra brilliancy is desired. At present we do not profess to explain the construction of this apparatus, but it is evident that it fulfils a most useful purpose.

Another device, of a somewhat more novel character, is that of the so-called "compensator," which is used in the central station in order to determine the actual difference of potential at any given moment at any point of the line. In the Edison system it will be remembered that this is accomplished by means of "pressure wires," which are run back to the station from the ends of the feeders. In the Westinghouse system the compensator is a species of impedance coil which is placed in series with a voltmeter, *and around the core of which the main current also flows*, the coils being so wound that the current in the main tends to decrease the reading of the voltmeter. Although the construction is not described in detail, it is easy to see that by plugging in more or less turns of the main coil the voltmeter can be made empirically to read the volts at any one of several points on the line. When the instrument has been adjusted for the required conditions, the dynamo-tender has then only to vary the resistance of the exciting circuit to keep the voltmeter needle at a proper reading. A similar device for continuous currents has, we believe, been carried out by the engineers of the Anglo-American Brush Company in England.

* See *Electrician*, August 26, 1887.

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The Westinghouse switches and fuse blocks, some of which were shown in this country a year or more ago, cannot be said to have created a very favourable impression. Even the largest switches here illustrated appear to be mounted on wood. This is a practice which certainly will not be followed in this country, even though it be proved that an alternating current has less tendency than a continuous current to form an arc under similar conditions. Speaking of lamp sockets in this connection we read :—"It must be remembered that the alternating current practically kills its own spark by its reversals, and hence the contact pieces in the socket suffer practically nothing from deterioration, and admit of the whole construction being direct and simple."

Our space does not admit of further detail in this issue, but next week we shall return to the subject.

(To be continued.)

THE ROYAL SOCIETY.

The annual meeting of the Royal Society was held at Burlington House on Friday last, when the Copley Medal was presented to Prof. Huxley for his morphological and histological investigations, and the Davy Medal to Mr. W. Crookes for his investigations on the behaviour of substances under the influence of the electrical discharge in a high vacuum.

At the anniversary dinner, held the same evening, in returning thanks for the health of "The Medallists," Mr. Crookes said :—In the absence of Prof. Huxley, who, unfortunately, is unable to be present this evening, I have been asked by our President to return thanks for the Medallists. The professor, in whose shoes I now stand, has lately put it on record that for twenty years he never rose to make a speech without his tongue cleaving to the roof of his mouth through sheer nervousness. I, on whom his duties have fallen, but, alas ! not his mantle, crave your indulgence for that nervousness for which I can quote so excellent an authority, and beg you to bear with me patiently in what must be as great a disappointment to you as it is to myself. Although I feel it embarrassing to take the place of a philosopher so renowned as Huxley, I am bound to say that even he cannot receive the Copley Medal—the ancient olive crown of the Royal Society, as it was called by Sir Humphrey Davy—without regarding it as the culminating honour of his scientific career. I am also bound to say that the award of this medal to such a man as Huxley confers at least as much honour on the Royal Society as on its renowned Professor. As regards the other recipients of the medals, Prof. Tacchini, the Romford Medallist, Baron Ferdinand von Müller and Prof. Osborne Reynolds, the Royal Medallists—coworkers with myself in the very varied departments of science—judging from my own feelings at the present moment, I cannot do better than express on their behalf the sincerest gratification at the high recognition you have bestowed on their scientific work. For my own part, as the Davy Medallist, I may perhaps be permitted to speak at somewhat greater length. Thirteen years ago in this very room, at the anniversary dinner of the Royal Society, I had the honour to return thanks to this Society for conferring on me the distinction of a Royal Medal. The President, Dr. Hooker, in handing to me the medal, referred to the then novel instrument the radiometer, and in the course of his remarks he made the following observation : — "It is the mystery attending this phenomenon that gives it its great importance. There is evidently some action going on with which we are not at present acquainted ; and there is no saying what a thorough investigation into the cause of the phenomenon may lead to." From that date to the present I have not ceased to work at the elucidation of the mysteries accompanying high vacua. During this interval of thirteen years the theory of the radiometer has been established on a firm basis. Since the advent of the radiometer the otheoscope has been devised and its action elucidated ; lines of molecular pressure in high vacua have been illuminated so as to render visible to the bodily eye those actions which hitherto had been seen only by the eye of faith ; molecular shadows have been projected ; luminous streams have been deflected and magnetised ; platinum has been melted by molecular impact ; the existence of matter in a fourth state—"radiant matter"—has been demonstrated ; and the strikingly brilliant phenomena of phosphorescence in high vacua have been discovered. The results of these investigations I have embodied in ten memoirs and Bakerian Lectures, which have appeared in the *Philosophical Transactions*, in eighteen Papers which have been inserted in the *Proceedings* of the Royal Society, and in fifteen other Papers published elsewhere. In the spectroscopic examinations which these researches necessitated, I constantly met with a bright, citron-coloured line, sometimes strong, at others only a ghost of a line, but always in the same place, and presumably due to the same cause. The hunting out of this phantom line has been a work of many years. At last I found it to be due to yttria, while a corresponding red line was tracked to samaria. Here a new field, indeed I may say a new world, of research unfolds itself to the chemist. The phosphorescent light from yttria gave in the spectroscope a complicated and beautiful series of coloured lines. But these lines varied in different specimens of the same earth from different localities, some being strong and others weak almost to extinction. Chemical tests showed that in each case the earth was free from known impurity, and for a long time the interpretation was inexplicable. I was confronted with a series of inscriptions from the molecular world, written in a strange and baffling tongue, and requiring a Rosetta stone to give the first step to decipherment. How the key of the mystery came into my hands, and what resulted therefrom, are now matters of history. The meaning of the lines, their positions and variations, is gradually becoming clearer and clearer, and to me this is what they seem to be saying. They tell me that in matter which responds to every test of an element, which possesses an atomic weight and combines with other matter in definite proportions, there still exist minute shades of difference among which a process of selection is possible. They tell me that the time-honoured distinction between elements and compounds, as it exists in the Lavoisierian and Daltonian chemistry, must be modified to make room for a vast array of intermediate bodies, or as I have elsewhere called them Meta-Elements, capable of isolation and identification. They tell me that there exist degrees of rank in the hierarchy of the chemical elements, some being, so to speak, more elemental than the others, some still waiting to be discovered, whilst others may have disappeared and are no longer existent under the conditions in which we are now placed. They tell me, again, that our chemical elements are products of the action of forces on a state anterior to matter, which I have designated as Protyl ; that these elements owe their present stability in that they are the outcome of a struggle for existence, a Darwinian development by chemical evolution ; that just as in the organic world we have the "survival of the fittest," so here we have the "survival of the most stable" or possibly of the "most inert." There are other lessons as yet only indistinctly whispered, lessons which, possibly to-day but certainly in days to come, will be seized on and interpreted. But I will no longer weary you with speculations which have not yet received full and final confirmation. It only remains for me to thank you for the high distinction of the Davy Medal—a distinction all the more welcome as it has only once previously been awarded to one of our own countrymen. I deeply appreciate the kind reception you have given me and the very gratifying remarks with which the presentation has been accompanied. Refreshed and stimulated by your friendly words of encouragement, I shall continue to apply myself to what Darwin called "the vivid pleasures of investigation." I shall attack with renewed energy the problems of radiant matter spectroscopy, and do my utmost "to pluck out the heart of the mystery."

CENTRAL STATION PRACTICE IN GERMANY.*

BY MR. F. J. PARSONS, PH.D.

Electric lighting on a commercial scale is not as old a thing in Europe as it is in this country [the United States], nor has it to this day attained to the same dimensions that it has here ; so you will not, I trust, be disappointed if I do not report to you any strikingly new developments in anything connected with central station lighting.

Theatres in Germany are mostly the property of either the general or the city Government, and no pains or expense have ever been spared to make them as good, and, above all, as safe as possible ; so it is not a matter of surprise to find the electric light first adopted in the theatres. The first theatre on the Continent to be lighted by electricity was the theatre in Brünn, the capital of Moravia, in the year 1882. Then followed, when this one proved to be such a success, the Royal Theatre at Munich at the time of the Electric Exhibition in that place in 1883.

This was the first station put in by the German Edison Company, and was but the first of a long series of similar enterprises all over the country.

As you see by the dates above mentioned the Germans were behind the Americans in point of time, behind even the English, for that matter, as the Savoy Theatre was lighted by electricity as early as 1881. But you can see the characteristic thoroughness with which the German does everything, from the fact that even in these first theatres that were lighted by electricity, that was the

* An address delivered to the Boston Electric Club.

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only method that was used, and there was no compromise made with gas, using electricity when everything worked well, and falling back on gas when a bearing got hot, or a fuse blew out, or any other of those untoward accidents happened that are so annoying in a large central station, and so absolutely disastrous in a comparatively small plant like that of a theatre. These theatres, however, are not even piped for gas at all, and to reduce to a minimum any danger of being left in the dark, the entire plant is put in in duplicate—lamps, wires, dynamos, engines, and everything; the only difference between the two being that the reserve plant is not as large as the one in ordinary use, so that if anything should happen to the regular plant in daily use the reserve plant could be immediately called into service, and the only difference would be, even if the first were entirely disabled, that the theatre would not be quite as brilliantly illuminated as before.

The motive power there, as here, depends on circumstances, being sometimes water, sometimes steam, and often gas engines. The Deutzer Gas Motor Company, for instance, furnishes excellent motors for electric light purposes up as high as 150 horse-power each, that do not use more than 15 cubic feet of gas per horse-power-hour, which, at the present price of gas in Berlin, makes an expense of only 1·2 cent. per horse-power-hour for fuel. Another advantage that gas motors have over steam engines in German cities is that a gas motor can be put up anywhere without special permission from the city authorities, and without increasing the insurance rates, while it is sometimes quite difficult to get permission to put up a steam engine.

In the business portion of Berlin it is only on the promise of taking the most extraordinary precaution to deaden the sound and to prevent accidents that one can get the necessary permission from the city authorities. For instance, the entire plant of the first electric light station is in the basement of a building on Friedrichstrasse, one of the busiest streets in Berlin, and, except for the white puffs of the exhaust steam that are seen to come out from the roof at night, no one even in the building could tell that there was a steam engine anywhere near them.

They use smoke-consuming furnaces, so there is no disagreeable smoke. All the foundations of steam engines and dynamos are carefully isolated from the foundations of the building itself, to prevent the inevitable vibration of the high-speed engines from being conducted to the walls of the building. The pulleys are covered with leather to deaden the sound of the running of the belts, and the exhaust steam is carried off so that you do not hear that characteristic sound, so that, even standing on the floor directly over the engines, it is impossible to tell whether they are in motion or not.

The question between one or two large low-speed engines and a larger number of small but high-speed engines has been decided, about as it has been in this country, that in most cases it is more economical to run a large number of small ones.

The method of transmission is about the same there as here, direct coupling being seldom used, but wire or hair ropes running in grooved pulleys are quite common. As to the dynamos used over there, there is perhaps not as large a variety in the market as here.

The two firms who have almost a monopoly in building dynamos for Germany are Siemens and Halske of Berlin, with an almost exclusive control over the market in North Germany, and Schuckert of Nürnberg, holding a similar position in South Germany. Schuckert was one of the first who was successful in making a compound dynamo that was of practical value, and as early as 1883 had built one that did not at any point vary more than one volt on gradually increasing the current from no load to full load. The Schuckert machine is a flat Gramme ring, which on account of the high peripheral velocity that it is possible to give to the armature without unduly increasing the speed, is especially adapted for a high constant potential. Still, by putting in plenty of iron to reduce the magnetic resistance of the ring, it is possible to make an excellent machine for incandescent lighting. By far the majority of dynamos in Germany, however, are built by Siemens and Halske.

The machines they build for stations that they run themselves are of the type best known, perhaps, in this country as the Kapp machine. Like all other machines built by Siemens and Halske, every part of the machine has been worked with the greatest care to make it comply with all the requirements of a dynamo built on scientific principles, and all the mechanical details are carried out with the most thorough workmanship. The armature core is made of iron wire wound in several distinct compartments around a frame insulated from the shaft, so that there is not the heating that one finds in the so-called Siemens armature, where the iron discs are in direct contact with the shaft, thus giving rise to eddy currents and not allowing for ventilation, while in the armature as built by Siemens and Halske there is abundant opportunity for ventilation. The winding is of course the usual Siemens', or, as it should be called, the Von Hefner-Alteneck method. The commutator itself is a very simple affair, consisting of the usual bars of copper, but only fastened at one end, and nothing but an air space between each for insulation. This commutator they have found very successful, and have adopted it on all their machines. Among other things it has this great advantage, if anything happens to one or two segments they can be taken out to be replaced by simply unscrewing one or two screws.

Besides these machines which they build for central stations that they put in themselves, they have a special contract, by the terms of which they have to furnish all the machines of the Edison type used by the German Edison Company. They are made with all the latest improvements both in the general form of the machine and in all its details; as in many other German machines that are intended to run at a high speed, the bearings are kept cool by a circulation of water being kept up around them. These machines, as they are intended for central station use in the strict sense of the word, are all simple shunt machines. Although there are those here, no doubt, who will dispute my statement, there is no question in the minds of electricians over there that it is more than useless to compound a machine that is to be used in any central station of any size, *i.e.*, in any station with more than one pair of feeders.

Especially useless in such a case is a machine that gives a rise in potential with an increase in the current, as that requires throwing in an unnecessary amount of resistance into any feeder that happens at the moment to be not very heavily loaded. In order to detect any ground the following device is a very common one:—Two lamps are connected in series between the two poles, and some point between is grounded. Then, if there is a dead ground, one of the lamps—which, of course, were before burning very low, at about 55 instead of 100—begins now to burn brightly, showing that there must be a ground on some connection to the other pole. In order to call the engineer's attention to this, and at the same time to serve as a more exact method of detecting a ground, the wire leading to the ground is passed through an electro-magnet that will ring on the passage of $\frac{1}{100}$ of an ampere, or detect an insulation resistance of 10,000 ohms. When they find that they have a ground somewhere, they have an arrangement so that by grounding the other pole of the machine, and by using a succession of different sized fuses, they can burn out the fuse of that particular branch on which the ground has taken place, and when the man in whose house it was complains that his fuse was blown out they know where the ground was.

The instruments used in the stations are, of course, the same as must be used everywhere, ammeters and voltmeters. The ammeters used usually make no pretence whatever to accuracy, and are graduated, not to amperes but lamps; so that the engineer reads off directly the number of lamps there are burning. In large central stations they have only one ammeter to each machine, so that the engineer can tell when his load has become heavy enough to throw in another machine. But in a small installation for lighting perhaps one large building or block of buildings, with only one or two dynamos besides the reserve, they have a current indicator on every branch that leads out from the switch-board. As they run their arc lights there usually two in series and each pair parallel to incandescent lamps on 100-volt circuits, that requires a little extra resistance to each lamp, so they usually run a separate circuit of iron or German silver wire from the switch-board to each pair of arc lights. As each one of these circuits has its own current indicator a station of that size will sometimes run from 15 to 20 current indicators, by means of which, however, the engineer can tell at a glance whether his lamps are all burning or not. But the thing that the engineer has to watch most carefully is his voltmeter. Gas being so much cheaper over there it is very much more difficult for electric lighting to compete with gas than it is here; so that it is only by producing an absolutely perfect light that they are able to find customers who are willing to pay the extra cost of electric lighting. Each machine has its voltmeter, and each feeder, has a return wire from the junction box with either a voltmeter that can be put in connection with each feeder in turn or else one voltmeter for each.

These are all carefully standardised by comparison with the Siemens' torsion galvanometer, which will read, when used with care, to within one half of 1 per cent.

Usually there is a voltmeter connected to the junction box of each feeder, and the voltmeter itself is arranged with an electro-magnetic bell attachment, so that an alarm is given when the potential varies over 1 per cent. from the normal.

As all electric light wires are underground it may be interesting to know how their cables are laid. In this department, as in so many others, Siemens and Halske have a practical monopoly. The cable they manufacture for the German Edison Company of Berlin consists of the necessary number of strands, and if of a large size, such as they use for their feeders, an additional wire is put in separately insulated from the rest, for getting the potential at the ends of the feeders. These are then added together in some insulating compound. Then by a patent process of their own this is encased in lead pipe.

In order to prevent the lead pipe from corroding it is then covered with hemp and soaked in asphalte. Then to prevent this covering

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or the lead pipe from getting damaged while digging up the streets for any purpose, the whole thing is then covered with a heavp strip of iron riband. Then, as a still further precaution, under all street crossings they lay old iron pipes, and draw this cable through them. Such a method has the further advantage that it does not necessitate closing the street either during the first laying of the cable or during subsequent repairs.

As you see from all this the laying of a system of underground cables as it is done there is a very expensive matter, so that the plan of laying it out with the different sizes to be used in the different streets has to be worked out with the greatest accuracy, especially where the demands for absolute constancy of light are as imperative as they are in Berlin, for instance. In order to do this a working model of the entire plant is made, consisting of a wooden frame or table, on which are marked off on a large scale the streets of that part of the city which they propose to light. The location of the central station is then decided upon, and marked down on the plan. Two wires are then run from a small battery to this point to represent the two poles of the station. Starting from here the whole plant is put in in miniature, thus covering the table with a double network of wires, representing the positive and negative lines, and separated from each other on the table by blocks of wood. Resistances corresponding to the different numbers of lamps are put in, and all the necessary experiments can be made to determine the size and location of the feeders. In order to determine the drop in potential from the central station to any given point, all that it is necessary to do is to join the positive and negative wires that we have on the table by means of a resistance corresponding to the number of lamps that are to be used, and then with a differential galvanometer, one branch of which receives its current from the battery representing the central station, and the other from the point at which the fall is to be determined, the fall in volts can be very easily determined.

In this way, for instance, can be determined better than by any calculation how many and how large feeders are necessary in any particular locality, in order that the potential shall not vary more than 1 per cent. or any other given amount, when 100 or 200 or 300 or any other number of lamps are suddenly thrown off or on, in the immediate vicinity. Thus, for instance, the two Royal theatres in Berlin are lighted from the two central stations of the German Edison Company, and it frequently must happen that all the lamps on both stages are thrown off or on at once, but it is impossible to detect so much as a waver in the light of the other lamps in the theatre, or in other buildings in the neighbourhood. This working model is always kept, and when additions have to be made, they are first tried on that small scale, in order to see what readjustments must be made to make the additions without interfering with the original plant.

The electricity being thus brought to your house, the next question is, how are you going to pay for it? Formerly the Edison zinc meters were used, but now they use almost entirely the so-called Aron's clock, a meter that was first suggested, I believe, by Prof. Perry, of England, but first put in a practical form by Aron. It consists simply of a pendulum clock, where the pendulum is a steel magnet. Behind or under this magnet is placed a coil of one or more turns of wire of very low resistance, through which the entire current that is to be measured is passed. The effect of a current passing through this coil is of course to retard the rate of the clock, if the current be going one way, or make the clock go faster if the current is going the other way. In practice the coil is always wound so as to make the clock gain, as that is found to give the best results.

The gain is a very decided one, so that any slight irregularity in the natural rate of the clock would not affect the result. For instance, in a clock intended to be used for 30 lamps, 1,000 lamp-hours will produce a gain of two hours. Supposing a man who has this 30-lamp clock to burn in reality only 15 on an average every evening, then in 66 hours the clock will have gained two hours. At the rate of five hours of an evening he would have a gain of two hours for his clock in 13 days, or a gain of about 10 minutes a day burning only half his lamps, and these clocks are warranted not to vary one half-minute per month when not under the influence of the current.

The lamps used there are suubstantially the same as those used here. They are made perhaps with more care and tested with more accuracy than is usual in this country, so that in a series of experiments on incandescent lamps made in the Polytechnic Institute in Berlin the Siemens lamps were found to come up to candle-power better when burning at the normal potential, and to have a longer life and a much better efficiency than the American lamps, though I suspect one reason was that the American lamps were not of the most recent manufacture.

In reply to a question put to him as to the nature of the contracts made for electric lighting in Germany and the method of calculating the cost, Mr. Parsons said that the number of lamps was not the basis for such undertakings, but rather the amount of illumination required. Thus, say a certain room had to be illuminated, the number of lamps would not be considered, but the meter candle-power illumination. This would vary from 8 or 10 meter candle-power for street lighting up to 50-meter candle-power, which gives a light by which one can read as well as by daylight, which has been found to be about 300-meter candle-power.

As to the running of dynamos, Mr. Parsons said machines up to any capacity whatever were always run in parallel. After one machine was run up to its full load then another machine would he started up, then the machines are thrown into multiple and gradually absorb the lights of the two; by this means an extra battery of lamps is saved. Not only are the machines run in multiple, but in Berlin the two central stations are run in multiple. They frequently use machines of different sizes.

In reply to another question, Mr. Parsons said that the potential was always maintained by hand, except in isolated installations where the machines being compounded they give very good results without hand regulation.

Asked if high-potential systems were used, Mr. Parsons said: There are very few plants in Germany that are run on what would be considered in America as a high potential. Electric lighting over there is confined almost exclusively to cities, where all wires are required to be laid underground, so that in addition to the natural cautiousness of the Germans about allowing such high potentials in their streets, there is the difficulty to encounter of making a successful insulation for high-potential currents that will last for any length of time underground without giving trouble. In Berlin the Khotinsky system is considered to use a rather high potential because they use a 150-volt incandescent lamp, and when they use arc lights put three in series. The station in Berlin run on this system was particularly interesting, as they used accumulators in addition to their dynamos, using only the accumulators for a light load and throwing on the dynamos as the load becomes heavier. Siemens and Halske made a long series of experiments with accumulators; but they found that they varied so much that they have not been able to do much with them.

PARLIAMENTARY NOTICES UNDER THE ELECTRIC LIGHTING ACTS.

Notification has been given in the *London Gazette* by several companies of intended applications to the Board of Trade, on or before the 21st inst., for Provisional Orders under the Electric Lighting Acts, 1882 and 1888. From the following summary of the various notifications it will be observed that, if the powers sought for be granted and acted upon, the electric light will soon be introduced on a commercial scale throughout London and the suburbs. Four notices are given by the Metropolitan Electric Supply Company (Limited), and two by the Chelsea Electricity Supply Company (Limited). Some of the notices, it will be seen, constitute competing schemes. The orders to be applied for outside the metropolitan area relate to Birmingham, Liverpool, Swansea, Brighton, Hove, and Dublin. In all cases there is great similarity in the powers sought for, which, generally, are for enabling the applicants to produce and sell the electric light; to erect and provide the necessary stations, engines, and works; to lay the wires, pipes, &c., for the supply; to break up the streets for the purpose; and to levy rates, &c.

The Metropolitan Electric Supply Company (Limited), of Winchester House, Old Broad-street. E.C., notify their intention of applying for four Provisional Orders for supplying—1. North London; 2. South London; 3. West London; and 4. Mid-London. By the first-mentioned order they ask for powers "to produce, store, supply, sell, and distribute electricity for public and private purposes" within the following area:—St. James and St. John, Clerkenwell; St. Mary, Islington; and St. Pancras and St. John, Hampstead. Authority is sought by the company to construct and maintain within the area of supply such central and other stations as may be necessary from time to time for the generation, storage, supply, and distribution of electricity and electric currents, together with all buildings, engines, and apparatus necessary or convenient for the purpose, and to lay down, maintain, &c., "electric lines, wires, conductors, mains, pipes, and other apparatus and works for the supply and distribution of electricity and electric currents in, over, along, or across all the streets, bridges, squares, courts, alleys, highways, lanes, roads, thoroughfares, and public passages and places within the area of supply." The order will contain clauses empowering the company to "break up and interfere with" streets, &c., within the area of supply, authorising them to purchase by agreement "lands and houses, and also patent rights and licenses or authorities for the use of inventions or protected processes relative to the production, supply, and distribution of electricity, and to manufacture, purchase, hire, and supply meters, lamps, appliances, machinery, and apparatus, for and in relation thereto;" authorising the company to enter into agreements with local authorities, companies, and persons as to the supply of electricity and the works required; empowering the company to make charges and levy rates for supplying electricity; defining and limiting the prices to be charged; exempting the company, under specified circumstances, from the obligation to supply electricity; and providing, if deemed necessary or expedient, for the subdivision of the area of supply. By this Provisional Order relating to South London the company seek similar powers in connection with the

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supply of electricity to Lambeth, otherwise St. Mary, Lambeth ; Christchurch, St. Saviour (including the Liberty of the Clink) ; Streatham, otherwise St. Leonard's, Streatham, and Clapham. The "parishes and places" in West London which the company seek to supply with electricity under similar conditions are St. Marylebone, Paddington, and St. Mary Abbot (otherwise St. Mary Abbotts), Kensington. In their Provisional Order relating to Mid-London the company seek for powers to supply the city of London and the Liberties thereof, and the following parishes and places in the county of Middlesex, viz. :—St. John the Evangelist and St. Margaret, Westminster ; St. George, Hanover-square ; St. Giles-in-the-Fields, St. George, Bloomsbury ; St. Andrew, Holborn-above-Bars ; St. George the Martyr, St. Sepulchre, Saffron-hill, Hatton-garden, Ely-rents, and Ely-place, the Liberty of Glasshouse-yard, St. Anne, Soho ; St. Paul, Covent-garden ; St. John the Baptist, Savoy, or precinct of the Savoy ; St. Mary-le-Strand, St. Clement Danes, and the Liberty of the Rolls, together with the extra-parochial places known as the Charter House, Gray's Inn, Lincoln's Inn, Staple Inn, Furnival's Inn, and the Close of the Collegiate Church of St. Peter.

The London Electric Supply Corporation (Limited), whose registered office is at 3, Adelphi-terrace, Strand, ask for powers to produce, store, supply, and sell "electricity, electric current, and other like agency" for public and private purposes in the following area :—St. Martin-in-the-Fields, St. Margaret and St. John (United) Westminster, St. James, Westminster ; St. George, Hanover-square ; Chelsea ; St. Mary Abbotts, Kensington ; Paddington ; St. Marylebone ; St. John, Hampstead ; St. Pancras ; St. Mary, Islington ; St. James and St. John (United), Clerkenwell ; St. Leonard, Shoreditch ; St. Luke ; in the Strand district, the St. Giles district, the Holborn district, the city of London, the Whitechapel district, and the parish of St. George's-in-the-East ; in the extra-parochial places of Lincoln's Inn, Gray's Inn, the Inner and Middle Temple ; in the district of Greenwich ; in the parishes of St. Mary, Rotherhithe ; St. Mary, Lambeth ; St. Mary, Newington ; St. George-the-Martyr, Southwark ; and St. Mary, Bermondsey ; the district of St. Olave, and the district of St. Saviour and Christ Church. The works proposed to be "constructed, used, and maintained" are described generally as follows :—A central station, or central stations, at which electricity will be generated or collected, and a system of distributing stations and mains by which electricity will be conveyed and distributed from the central station or stations throughout the area of the supply. In other clauses the necessary powers were sought as to the acquisition of lands, arrangements with local authorities, interference with streets, &c., in the area of supply ; exemption from the Metropolitan Building Acts, and the levying of rates and charges.

The Electrical Power Storage Company (Limited), of 4, Great Winchester-street, E.C., intend to apply for a Provisional Order, authorising them to produce, store and supply electricity for all or some of the public and private purposes defined by the Acts of 1882 and 1888, within the following areas :—In the parish of St. Martin's-in-the-Fields :—West Strand, Cecil-street, Salisbury-street, Ivy Bridge-lane, Adam-street, Adelphi-terrace, Robert-street, John-street, James-street, William-street, Durham-street, Buckingham-street, York-place, George-court, York-buildings, York-terrace, Villiers-street, Victoria Embankment, Brewer's-lane, Northumberland-passage, Craven-street, Northumberland-street, Northumberland-avenue, Great Scotland-yard, Charing Cross, Craig's-court, Duncannon-street, St. Martin's-place, Chandos-street, St. Martin's-mews, Adelaide-street, King William-street, Exeter-street, Burleigh-street, Whitehall-place, Middle Scotland-yard, Whitehall-yard, Eagle-court. In the district of the Strand Board of Works :—The Strand, Thanet-place, Palsgrave-place, Devereux-court, Essex-street, Little Essex-street, Milford-lane, Water-street, Arundel-street, Howard-street, Norfolk-street, Surrey-street, Strand-lane, the Approach, Victoria Embankment, Wellington-street, Savoy-street, Savoy-hill, Church-row, Beaufort-buildings, Herbert's-passage, Fountain-court, Somerset-street, Carting-lane, Cecil-street, Burleigh-street, Exeter-street, Wellington-street, Catherine-street, Helmet-court, Angel-court, White Hart-street, New Church-court, Drury-lane, Feather's-court, George-yard, Windsor-court, Denham-court, Drury-court, Newcastle-street, Holywell-street, Wych-street. Power is asked enabling the company to purchase or lease land, and to erect and work thereon all necessary stations, engines, &c. ; and the company also seek to be empowered to "manufacture, hire, sell, and let all necessary machines, lamps, accumulators, meters, fittings, plant, machinery, and other matters or things" required for the purposes of the order, and "to acquire, work, and use patents and licenses for patents for the making, producing, controlling and measuring, or otherwise, relating to the supply of electricity."

The House-to-House Electric Light Supply Company (Limited), whose registered office is at 117, Bishopsgate-street Within, E.C., will apply for a Provisional Order to supply electricity for public and private purposes for such period as shall be prescribed within the following area :—All the streets and thoroughfares in the parish of St. Mary Abbotts, Kensington (other than High-street, from its eastern end as far west as the Kensington High-street Railway Station, King-street, Church-street, Ball-street, Kensington-square, Young-street, James-place, Charles-street, Kensington-court, Prince of Wales'-terrace, Victoria-road, Cambridge-place, Albert-place, Douro-place, St. Alban's-road, De Vere-gardens, Palace-gate, Canning-place, Hyde Park-gate, and Kensington-gate), and also the following private streets : — Adam and Eve-mews, Adrian-mews, Albert-mews, Alveston-mews, Ashburn-mews, Atherstone-mews, Avenue (The), Barkstone-gardens, Bolton-mews, Bolton Studios, Bramham-gardens, Bremner-road, Canning-mews, Chelsea-grove, Cleveland Terrace-gardens, Cluny-mews, Collingham-gardens (west of Collingham-road), Courtfield-mews, Cranley-mews, De Vere-mews, Evelyn-terrace, Evelyn-gardens, Egerton-gardens, Elm-mews, Farnell-mews, Faucett-mews, Gaspar-mews, Grenville-mews, Harrington-mews, Hyde Park-gate, Holmes-place, Hollywood-mews, Jay-mews, Kramer-mews, Kensington-crescent, Kensington-gate, Kingsley-mews, Lexham-mews, Ligon-mews, Logan-mews, Nevern-square, Old Manor-yard, Onslow-mews, Ovington-mews, Dennant-mews, Pembroke-place West, Philbeach-gardens (Warwick-road), Queensbury-place, Queensbury-mews, Radley-mews, Redcliffe-mews, Roland-gardens, Shaftesbury-mews, Stratford-avenue, Sydney-mews, Tarn-mews, Victoria Grove-mews, Wynnstay-gardens, Abbey-road, Airlie-gardens (north side), Albion-place, Bassett-road (west of St. Mark's-road), Bransford-street, Branstone-street, Campden House-mews, Colville-mansions, Colville-mews, Colville Square-mews, Drayson-mews, Edinburgh-road, Fowell-street, Golden-mews, Hansard-mews, Hayden's-mews, High Lever-road, Lambton-mews, Linden-gardens, Linden-mews, Lorne-gardens, Murchison-mews, Observatory-gardens, Oxford-gardens (west of St. Mark's-road), Oxford-mews, Palace Gardens-mews, Railway-mews, Roseland-place, Ruston-mews, St. Helen's-gardens, Silvester-mews.

The Provisional Order for which the Westminster Electric Supply Corporation (Limited), of Victoria-mansions, Victoria-street, Westminster, will apply seeks for powers authorising the company to supply electricity for public and private purposes in the Parishes of St. Margaret and St. John the Evangelist, in the City and Liberties of Westminster ; in the Board of Works district for the Strand ; in the Parish of St. George, Hanover-square, in the City and Liberties of Westminster ; in the Parish of St. Peter's, in the City and Liberties of Westminster ; in the Parish of St. Martin's-in-the-Fields, in the City and Liberties of Westminster ; in the Parish of St. James's, Piccadilly, in the City and Liberties of Westminster.

The Chelsea Electricity Supply Company (Limited) will ask for powers to produce, store and supply electricity within that part of the Parish of St. George, Hanover-square, which is to the east of the boundary of Chelsea parish. Among the streets, &c., more particularly proposed to be supplied (but not to the exclusion of the other streets and places within the said area) are Belgrave-square, Buckingham Palace-road (part of) ; Chapel-street, Chesham-place, Chesham-street, Chelsea Bridge-road (part of) ; Chester-place, Chester-square, Chester-street, Chester-street (west) ; Chester-terrace, Eaton-place, Eaton-place (West) ; Eaton-square, Eaton-terrace, Ebury-street (part of) ; Eccleston-street, Elizabeth-street, Grosvenor-place, Grosvenor-crescent, Halkin-street, Halkin-street (west) ; Hobart-place, Knightsbridge (part of) ; Lower Belgrave-street, Lower Grosvenor-gardens, Lowndes-place, Lowndes-street (part of) ; Lyall-street, Motcombe-street, Pimlico road (part of) ; Pont-street (part of) ; Upper Belgrave-street, Upper Eccleston-street, Upper Ebury-street, Upper Grosvenor-gardens, Westbourne-place, Wilton-crescent, Wilton-place, Wilton-street. Similar powers are asked by this company in another Order for supplying that part of the parish of St. Mary Abbotts, Kensington, which lies south of the Brompton, Old Brompton, and Richmond roads, west of Ovington-gardens, and is bounded on the south by the northern boundary of the parish of Chelsea. The notice states that "it is more particularly proposed to place electric lines and works in, over, and along the whole or portions of the following streets and places" (but not to the exclusion of the other streets and places within the said area) :—Boltons, Brompton-crescent, Brompton-road (part of), Cathcart-road, Cranley-gardens, Cranley-place (1), Cranley-place (2), Drayton-gardens, Egerton-gardens, Egerton-gardens-mews, Exhibition-road (part of), Elm-place, Finborough-road, Foules-terrace, Fulham-road, Gilston-road, Harcourt-terrace, Harley-gardens, Highfield-road, Hollywood-grove, Michael's-grove, North-terrace, Old Brompton-road, Onslow-crescent, Onslow-gardens, Onslow-houses, Onslow-square, Ovington-gardens, Ovington-square, Pelham-crescent, Pelham-place, Redcliffe-gardens, Redcliffe-road, Redcliffe-square, Redcliffe-street, Richmond-road (part of), Roland-gardens, Roland-houses, Selwood-place, Seymour-place, Sumner-terrace, Sumner-place, Sydney-place, Thurloe-square, Tregunter-grove, Tregunter-road.

The Kensington and Knightsbridge Electric Lighting Company (Limited), or the Kensington Court Electric Lighting Company (Limited), or both of them, whose offices are in High-street, Kensington, will apply for an order to produce, store, supply, and sell electricity, electric current, "and other like agency" for public and private purposes, within the parish of Saint Mary Abbotts, Kensington, and so much of the parish of Saint Margaret, Westminster, as lies to the west of the parish of St. George, Hanover-square.

The Notting Hill Electric Lighting Company (Limited), of 20, Great Winchester-street, E.C., will ask in the Order for which they intend to apply, for powers to produce, store, and sell electricity in the parish of St. Mary Abbotts, Kensington.

The Brighton Electric Supply Company (Limited), of 47, Gloucester-road, Brighton, will ask for an Order to supply electricity, for public and private purposes, in the borough of Brighton, the parish of Preston, and in the town of Hove.

The Liverpool Electric Supply Company (Limited), of 1, Crosshall-street, Liverpool, in the Order for which they notify their intention of applying will ask for powers "to produce, supply, and store electricity for lighting and other purposes" in the city. The area of supply is described as so much of the city and parish of Liverpool as is surrounded by a line drawn from the bottom of Chapel-street, up that street, thence along Oldhall-street, Great Howard-street, Leeds-street, Vauxhall-road, Midghall-street, Standish-street, North-street, Dale-street, Byrom-street, Clayton-street, Mill-lane, Islington, Norton-street, London-road, Anson-street, Pembroke-place, Ashton-street Brownlow Hill, Bedford-street North, the north and east sides of Abercromby-square, Chatham-street, Falkner-street, Grove-street, Huskisson-street, Hope-street, Upper Duke-street, Duke-street, Hanover-street, the south side of Canning-place, Strand-street, Back Goree to the bottom of Chapel-street, including in all cases the houses and buildings on both sides of the streets and places above mentioned.

Application will be made by Messrs. Arthur Chamberlain and George Hookham, of New Bartholomew-street, Birmingham, for an Order to supply electricity for all public and private purposes in the borough of Birmingham, and with such object to break up public and private streets, railways, tramways, and other places in the borough, and to erect, construct, lay

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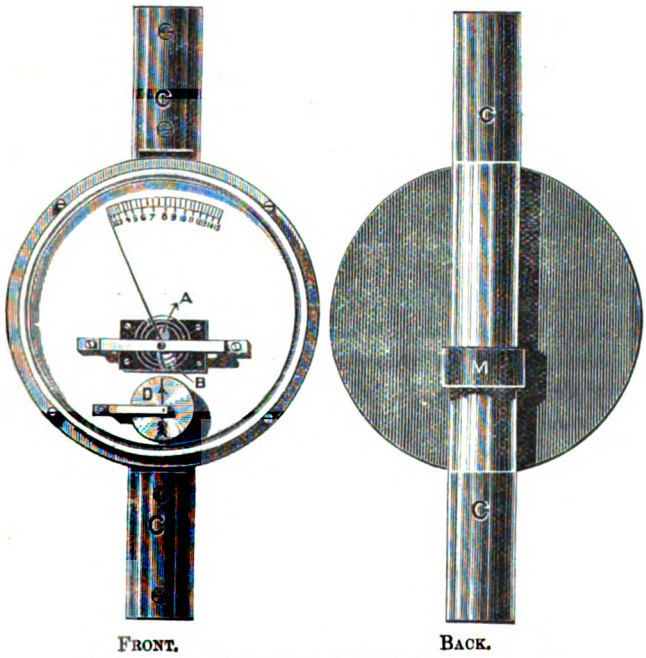
down, provide, and maintain mains, wires, and other apparatus and works; to acquire land and other rights, and to supply lamps, meters, and fittings. The notice states the area of supply within which it is proposed that the provisions of the Order shall be in force and have effect is the whole of the said borough of Birmingham, as constituted at the date of the proposed Order, but (subject to powers and conditions of extension at the instance of the undertakers, or the local authority to be inserted in the proposed Order) the area to be compulsorily supplied within three years of the date of the Order shall be so much of the borough of Birmingham as lies between the line formed by the following streets, or parts of streets, viz.:—From the junction of Edmund-street and Easy-row along Edmund-street to its junction with Livery-street, thence along Livery-street to its junction with Colmore-row, along Colmore-row to its junction with Bull-street, along Bull-street to its junction with the Minories, along the Minories to its junction with the Old-square, thence round the Old-square to the corner of the Upper Priory, thence continuing round the Old-square, down Corporation-street to its junction with Lawrence-street, thence back along Corporation-street to its junction with Bull-street, along Bull-street to its junction with Albert-street, along Albert-street to its junction with Fazeley-street, along Fazeley-street to its junction with New Canal-street, along New Canal-street to its junction with Bordesley-street, along Bordesley-street to its junction with Park-street, along Park-street to its junction with Paternoster-row, along Paternoster-row to its junction with Moor-street, along Moor-street to its junction with Carr's-lane, along Carr's-lane to its junction with High-street, along High-street and down the Bull Ring to its junction with Moor-street, thence across the Bull Ring and along Bell-street to its junction with Worcester-street, thence along Worcester-street to its junction with New-street, along New-street to its junction with Paradise-street, along Paradise-street to its junction with Easy-row, and thence along Easy-row to its junction with Edmund-street.

Application will be made by the Corporation of Swansea to produce, store, and supply electricity within the borough; to manufacture, purchase, hire, sell, and let all necessary machines, lamps, accumulators, meters, fittings, plant, machinery, and other matters or things required for the purposes of the Order; and to acquire, work, and use patents for the producing, storing, controlling, and measuring, or otherwise relating to the supply of electricity.

The Corporation of Dublin will apply for powers to supply electricity for all public and private purposes within the city.

AMMETER FOR LARGE CURRENTS.

The instrument illustrated below is being introduced by Messrs. Paterson and Cooper for the measurement of large currents, and contains several valuable improvements made by Mr. S. Joyce, one of their electrical staff. It is of the electro-magnet type, and consists of a round bar of copper, C C, nearly encircled by a split



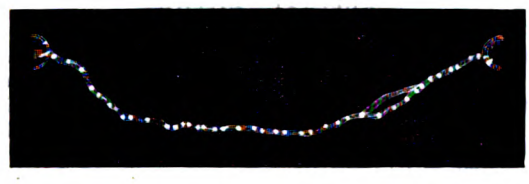
FRONT. BACK.

Paterson and Cooper's Ammeter for Large Currents.

soft iron ring, M. On the ring on opposite sides of the gap are fixed pole-pieces, between which is pivoted the soft iron needle A. The needle is mounted on an axle working in jewelled centres, and is maintained at zero when no current passes by a spiral spring, as shown. The deflection is indicated by a pointer, which is balanced by a counterweight, B. When the current passes through the copper bar the ring is magnetised and the needle is deflected. The dial is marked proportionally to the current, the instrument illustrated measuring 1,500 amperes. The dial and the working parts are screwed directly on to the copper bar, the construction admitting of great strength and durability, since no insulation is employed. The small disc D has a magnetised needle fixed at its back, so as to indicate the direction of the current. The accuracy of the indications is unaffected by all ordinary positions of the leads to and from the instrument, it being found that when a return is passed down at the back parallel to C C, and within one inch of the iron ring, the deflection is altered by only one per cent. Being an electro-magnet instrument there is no recalibration required, nor is there any perceptible error due to residual magnetism. It is made in sizes from 300 to 2,500 amperes or more, and the calibration is effected direct by comparison with one of Sir W. Thomson's kilo-ampere balances.

THE DURATION OF LIGHTING FLASHES.

It is well known that the lighting flash, or the spark between the terminals of an influence machine, exists for so short an interval of time as to be beyond measurement by any ordinary means. But notwithstanding the acceptance of this knowledge, the peculiarities of some of the flashes photographed have been supposed to be due to the camera, or the sensitive plate, being at the time in a state of vibration. To test this line of thought, Mr. James Wimshurst has made a dark slide for his camera, in which is fitted a train of clockwork carrying a disc, upon which is an arrangement for holding the sensitive plate. When all is com-



plete for photographing a flash, the clockwork is wound up, the sensitive plate then rapidly acquires great velocity, which at the maximum reaches 2,500 revolutions per minute, and with the plate rotating at this speed the spark is photographed. The annexed engraving is from a photograph taken under these circumstances; as will be seen, it in no way indicates movement in the sensitive plate, for the photograph throughout its length is as sharp and as clear as though the plate had been at rest. The experiment is interesting, for it not only shows the infinitely short existence of the spark, but it also shows that chemical change in the sensitive film takes place in an equally minute interval of time.—*Engineering.*

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, December 8th.

PHYSICAL SOCIETY.

3 p.m. "On Some Facts Connected with Systems of Scientific Units of Measurements." By Mr. T. H. BLAKESLEY.

MONDAY, December 10th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. "Light and Colour." By Capt. W. de W. ABNEY, C.B., F.R.S. (Third Lecture.)

TUESDAY, December 11th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Discussion on Mr. J. Oliver Arnold's Paper on "The Influence of Chemical Composition on the Strength of Bessemer Steel Tyres."

ROYAL VICTORIA HALL.

8:30 p.m. Lecture, "Limestone Rocks and their History." By Mr. EDWARD WETHERED, F.R.S.

WEDNESDAY, December 12th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Explosives." By W. H. DEERING F.C.S.

THURSDAY, December 13th.

SOCIETY OF TELEGRAPH ENGINEERS.

8 p.m. Annual General Meeting. Election of Council. Conclusion of the Discussion on Mr. HENRY EDMUNDS' Paper "On a System of Electrical Distribution."

FRIDAY, December 14th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "The 26-Knot Spanish Torpedo-Boat 'Ariéte.'" By JULIAN KING-SALTER, Stud. Inst. C.E.

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
Within Postal Union	6 6	12 6	24 0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

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"The Electrician" offers exceptional advantages to Advertisers. **It has the largest circulation of any English Electrical paper, and circulates all over the World.**

Particulars relating to Advertisements will be promptly forwarded on application to this office.

Trade Advertisements *intended for the current issue must be handed in not later than First Post on Thursday morning.*

Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

TECHNICAL PRINTING.

"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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At the commencement of each year is issued The Electricians' Directory and Handbook. *The Directory was established in 1888, and has now attained considerable proportions. Every care is taken to make the names and addresses of all persons engaged in the Electrical Industries absolutely accurate. Useful Tables and Electrical Formulæ are given, together with popularly-written Biographical Notices of the leading Electricians, accompanied in many cases by Portraits.*

THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received,

CONTENTS OF THE CURRENT NUMBER.

Notes	123
Lightning Conductors. — IV. By Dr. Oliver Lodge. Continued	128
The Westinghouse Electric Company	129
The Royal Society	131
Central Station Practice in Germany. By Mr. F. J. Parsons, Ph.D.	131
Parliamentary Notices under the Electric Lighting Acts	133
Ammeter for Large Currents. Illustrated	135
The Duration of Lighting Flashes. Illustrated	135
Meetings of Scientific Societies	135
Electric Traction	136
The Geyer-Bristol Meter for Direct and Alternating Currents. By Prof. William E. Geyer. Illustrated	137
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued	138
Legal Intelligence—	
King, Brown and Co. *v.* The Anglo-American Brush Electric Light Corporation. Ill.	140
Edison and Swan Electric Light Company *v.* Holland and Others	143
American Notes	146
Correspondence	147
Works of the Woodhouse and Rawson Manufacturing Co. at West Kensington. Illus.	150
Electric Lighting and the Kensington Vestry	151
Companies' Meetings, &c.—	
Maxim-Weston Electric Co.	151
City Notes, &c.	153
Companies' Share List	154

"THE ELECTRICAL WORLD" IN THE UNITED KINGDOM.

Arrangements have been made by which "The Electrical World" of New York can be obtained from "The Electrician" Office, 1, Salisbury-court, Fleet-street, London, E.C.

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VOLUME XXI. OF "THE ELECTRICIAN."

Volume XXI. of "The Electrician" is NOW READY,

Price 12/6, post free 13/6.

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ELECTRIC TRACTION.

The report presented at the meeting of the Blackpool Electric Tramway Company (which was printed in our last issue) may be held to prove that this undertaking has finally emerged from the experimental stage and has developed into a commercially prosperous concern. An increased traffic of nearly 100,000 passengers, making a total of over 700,000 for the year, with a mileage of 90,000 miles, a dividend of 4 per cent. on a paid up capital of £20,000, and a sum of £1,000 carried to the reserve fund, are all unmistakable evidences of practical success, and give every reasonable promise of a prosperous future. But whilst congratulating Mr. Holroyd Smith, the directors, and shareholders on this result, we would take occasion to emphasise the fact that it has far more than a local significance; indeed, we hold that it has, or should have, a most important bearing on the future of electric traction in this country. Its importance arises, as all who are conversant with the circumstances will be aware, from the fact that the Blackpool line is one of the very few existing lines upon which the conduit system is employed. With the exception of the Gravesend line, which the Series Traction Syndicate is now constructing,

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no other conduit line exists in this country, and but very few—not more than five or six to our knowledge—in America.

The two or three remaining lines in this country, and the majority of those on the Continent, are worked with currents taken off either from one of the ordinary rails, or, more often, from a special third rail; and it is a striking fact that, notwithstanding all that has been said and done in respect of battery traction, we cannot at present point to a single existing illustration of its use in this country. In Brussels, after extensive trials of the Julien system, it has not led to results of a satisfactory character; at Lisbon the same system has just been replaced by that useful animal the mule. In Paris it is true that a line of battery cars has been running between the Porte Maillot and L'Etoile during the last few weeks, but for too short a time to judge of the ultimate result. In Germany and Austria we are unable to recall a single instance of the use of battery cars. In America, so far as our information extends, there are at present three such lines—still, however, in the experimental stage (as against some 80 or 90 worked by overhead lines); whilst in London we must not forget to mention that the Electric Traction Company will shortly have six trams running on the line between Barking and Canning Town. At Birmingham also we have recently mentioned some trials which, so far as the mere working of the car is concerned, have been quite successful. If we finally add that some important orders have recently been fulfilled for Australia, we shall have pretty nearly exhausted the existing evidences of the commercial feasibility of the method in question.

In saying all this, we wish at the same time to make it perfectly clear that we by no means despair of the future of battery traction. We have recently spoken of this as the *ideal* solution of the problem, provided only that we can obtain the ideal cell. And although that may be, and almost certainly is, an unrealisable standard of perfection, still we do look forward to the time when the battery will have arrived at such a stage of development as to admit of its utilisation for the purposes of electric traction with that degree of confidence which alone entitles a scheme to take rank as a commercial as distinguished from an experimental process. Meanwhile, facts are facts, and until we see the balance-sheet of a company in which a dividend has been paid on the results of this method of working, we must decline to regard it as standing upon the same commercial footing as the other systems to which we have referred.

Seeing the unquestionable and much higher degree of success which batteries designed for lighting have now attained, it may be useful to inquire why this is so. The inferiority of the traction battery is partly accounted for by lack of experience. The experience gained in lighting is at least a hundredfold as great; and yet it has not been until the present year of grace that the E.P.S. Company has developed a cell which may be considered as at least approximating to a final form. This is a deficiency which can only be allowed to work its own cure. Another point of more fundamental importance is to be discovered in the fact that, in order to reduce the weight of traction cells within workable limits, the current density is required to be very considerably greater than in other cases. For lighting work a current density of 1 ampere per 30 or 40 square inches of positive plates is common practice, whilst in the cases which have come under our notice for tractive purposes an output of 1 ampere per 12 to 18 square inches was usually obtained. This consideration is alone sufficient to emphasise the wide distinction between the two problems. Again, the variations in the load on the traction battery, which are necessarily so frequent and so extreme, are highly detrimental to the life of the plates, whilst this state of things is seldom or never paralleled in the case of batteries used for lighting. The weight of the cells is an objection which operates as a function of the second or third degree; for it not only demands a more substantial and, therefore, heavier car and a more powerful motor, but this in itself involves additional cells to accomplish the work, and so on, like the hare and the tortoise. So that, on the whole, we should scarcely be surprised if in the end we are led to the abandonment of lead batteries for this particular purpose. We are, nevertheless, glad to state, from facts which have recently come to our knowledge, that substantial improvements have been made in the design of lead batteries for traction work, and next week we shall probably have an opportunity of putting before our readers some results which we believe to be the best hitherto attained.

Tramway companies are very naturally averse to any innovation which involves a structural change in their lines, and there are, doubtless, many cases in which the conduit would be just as inadmissible as the overhead system so much in vogue in America. Nevertheless, the results achieved at Blackpool are full of encouragement, and where there is no fundamental objection to the introduction of this system, we feel confident that it would be accompanied by increased dividends to the shareholders. We may add that the little tramway on the Ryde Pier, which is worked on a third rail system, has been shown to cost 25 per cent. less than when horse traction was employed.

THE GEYER-BRISTOL METER FOR DIRECT AND ALTERNATING CURRENTS.*

BY PROF. WILLIAM R. GEYER.

In the meter about to be described we make use of the heating effect of the current. Electric measuring instruments depending on this heat effect are not new, as in the Cardew voltmeter we have an application which has found much favour. Here the current of greater or less strength traverses a long thin wire, heats it more or less, and the direct expansion is a measure of the current, and indirectly of electromotive force.

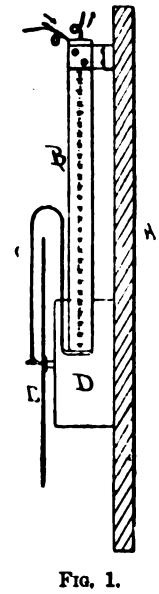

FIG. 1.

In an ammeter it is necessary to keep down the resistance, and I therefore doubt whether direct expansion can be usefully applied for this purpose; for the actual elongation of a bar of metal, even when raised through a considerable range of temperature, is very small. In the familiar compound bar we have a case where a very small actual elongation produces a relatively very great lateral displacement.

I think I shall best be able to explain to you our meter by recall-

* Read before the American Institute of Electrical Engineers, New York, Nov. 13, 1888.

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ing to your minds this old device. In the simplest compound bar two strips of metal which have different coefficients of expansion are securely soldered flatwise along their entire length. Brass and steel are metals frequently employed. On heating, the brass expands more than the steel, and, in consequence, the bar bends, becoming convex on the side of the brass. When such a bar is heated by the passage of the electric current it will deflect, and this deflection may be made a measure of the current. The disadvantage of such an instrument would be that atmospheric changes of temperature would also cause deflection, so that troublesome corrections would have to be introduced.

In our meter we also use a sort of compound bar, but eliminate at once the effect of the surrounding temperature by taking metals whose coefficients of expansion are the same or sensibly equal—in fact, we take the same metal. Our first form of construction was as follows :—A wire of German silver is laid upon a strip of German silver of considerably greater cross-section and radiating surface. The wire and strip are soldered together at one end, separated for the remainder of the length by a film of mica, then tied together at frequent intervals with silk or other insulating material, and suitably supported or clamped at the unsoldered end. If now a current,

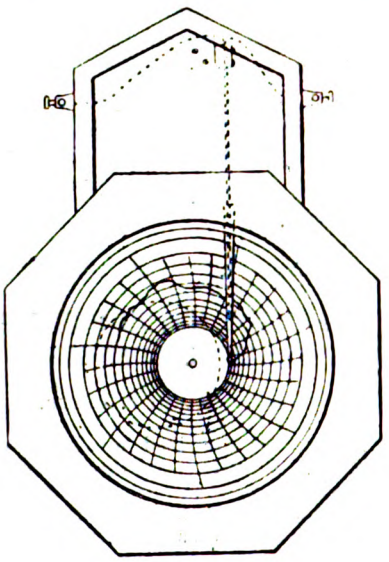

Fig. 2.

either continuous or alternating, is allowed to enter the strip at one end, it runs along its length, there enters the wire, and leaves the instrument at the other end of the wire.

For a given current the wire, on account of its greater resistance, and also on account of its smaller radiating surface, becomes hotter than the strip. In consequence of the difference of expansion the bar bends, becoming convex on the side of the smaller conductor. This combination we call a differential bar.

We would also state that inasmuch as the results obtained by the use of this instrument are due to the excess of the heating effect of an electric current upon one portion of the bar, or its equivalent, over the other, it is in a measure immaterial to the principle of the invention whether the current which produces the differences in temperature be caused to heat the two parts directly or indirectly. For example, the more expansible part, in lieu of being included directly in the circuit, may be arranged in close proximity to, but insulated from, a wire or conductor which is heated by the current. The other part or element may be in the circuit or not, but in either case formed or arranged to be less sensibly heated than the other.

It will readily be seen, however, that to heat one or both of the parts of the device in this manner would be clearly equivalent to connecting them both in series in an electric circuit. Unlike the case where magnetic action is employed, the force here available is very considerable, so that, to make the instrument self-recording, it is only necessary to attach an inking device to the free end and move in front of it a properly ruled chart. In this respect we have no difficulty whatever. My associate, Prof. Bristol, who has done the larger part of the work, has, since our first experiments, very much simplified the method of constructing the differential bar, and the one used in the instrument exhibited was made by placing a flat strip of German silver between a pair of dies which make alternate depressions and elevations along the length of the bar ; the wire, insulated with asbestos, was then slipped in the tube-like space thus formed, and the whole pressed between plates provided with grooves of the proper depth so as to leave the wire to one side of the centre line and at the same time to insure its being held firmly by the little bridges along the length of the bar. Since the bars can be constructed essentially by these two machine operations it is evident that they may be readily reproduced and at very small cost.

We have determined experimentally the best relation between the cross section of the strip and wire to give maximum deflection. We believe the instrument could readily be made integrating, but doubt the desirability of doing so. Our reason for this could probably not be better expressed than in the words of an eminent engineer, Mr. Charles E. Emery, in his Paper on "Heating Cities by Steam," before the Franklin Institute, which we quote as follows :—

"It was at first considered unfortunate that a reliable meter could not be obtained, which, like a water meter, would show by differences of reading the quantity of steam used for the interval between observations directly without calculation, and without expense of maintaining a time register at each location, and of integrating the charts afterwards. This system, however, proved a blessing in disguise. The greatest difficulty in settling with consumers lies in the fact that *employés* waste the steam. This is particularly the case during the heating season, when steam for various uses is left on continuously during nights and Sundays, thus increasing the time of consumption from, say, 60 hours a week to 168 hours. In many cases, too, the rate of consumption keeps uniform during the night as well as during the day, so that it is an easy matter to more than double the bills. The consumers at first naturally lay the blame to the steam of the steam company, but the meter charts have been the means of enabling the company to satisfy consumers when, and to what extent, the increased bills were due to mismanagement on their premises."

Substitute electricity for steam and the reasoning will apply perfectly to our case.

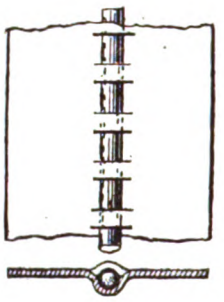

Fig. 3.

In the accompanying illustrations Fig. 1 is a general view of the differential bar, mounted in a case, with inker and recording dial. Fig. 2 is a side view of the important parts, the case being removed.

The following letters refer to the different parts :—

A, supporting framework ; B, differential bar ; C, inking pointer attached to bar ; D, clockwork moving dial ; E, revolving dial for receiving record.

Fig. 3 shows a small portion of the bar and a cross section on an enlarged scale.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section II.—Electro-Magnetic Fields.

(*Continued from page 80.*)

137. *Magnetic Susceptibility.*—As Science moves onward she draws in her train an ever-increasing number of newly-coined or adopted words and names, to each of which she assigns a definite *rôle*—that of representing with rigid exactness some new idea or phenomenon, or perhaps of being the more concise representative of some already known but hitherto undefined property of matter. Perhaps in no paths of discovery has she so far perpetuated in this manner the names of those who have worked laboriously in her cause as in electrical and allied researches, in which such famous names as Volta, Ampère, Ohm, Coulomb, Faraday, Joule, and Watt are constantly in use by those who are engaged in developing the many practical applications turning on their discoveries. It sometimes happens, however,

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that science presses into her service words which have been more or less in the familiar use of common parlance. When, however, such words are "told off" to serve her, she requires that, whatever variety of garb they may choose to wear in their capacity as civilians, one distinctive uniform only must be worn when they are enlisted in her corps and on duty in her service. In other words, science requires that definite ideas shall be represented by special terms set apart exclusively for their use. As instances, we might cite such words as force, strength, mass, intensity, power, work, energy, capacity, &c., which all have considerable flexibility of meaning in ordinary use, but only one distinctive meaning in their scientific application.

The word "susceptibility," which we are about to consider, has been told off to express a state or condition of iron in which it is more or less "susceptible" of becoming magnetised under the action of electromagnetic force. In the familiar use of the word we speak of "susceptibility to pain," "susceptible of impressions," "susceptible to charms," &c., and, turning to see what Johnson says, we find he quotes a sentence from "Wotton" to illustrate its meaning as follows:—"He moulded him platonically to his own idea, delighting first in the choice of materials, because he found him *susceptible* of good form." Put into the simplest language, we may say that great or little susceptibility conveys the idea of the ease or difficulty with which an acting cause produces a corresponding effect. When the subject operated upon possesses great susceptibility a given acting cause can produce a great effect, but when it has little susceptibility the same acting cause can produce but little effect. The subject operated upon in our present case is iron, the acting cause magnetising force, and the effect the magnetisation produced. Iron is said to have a greater maximum *magnetic susceptibility* than steel, because under a given magnetising force it acquires a higher intensity of magnetisation. Also, the magnetic susceptibility of iron or steel varies according to the state of magnetisation. On applying a gradually-increasing magnetising force to iron its susceptibility is at first small, then increases very rapidly to a maximum, and then falls again almost to zero. This may be noticed in the curves already worked out.

We may now define magnetic susceptibility (usually denoted by the Greek letter κ) as the ratio between I, the intensity of magnetisation acquired, and H, the acting magnetising force, and write it

$$\kappa = \frac{I}{H}.$$

For example, taking the higher curve in the last figure it will be noticed that for a magnetising force of 10 C.-G.-S. units the magnetisation acquired is 800, and therefore the susceptibility is 80. This is at the steepest part of the curve, and is therefore the maximum susceptibility in this specimen. As the iron becomes practically "saturated" at the sharp bend of the curve the susceptibility is reduced to $\frac{1200}{30} = 40$, and at the highest magnetising force employed (170 C.-G.-S. units) it becomes very small, viz., $\frac{1330}{170} = 8$ nearly.

Prof. Ewing found the susceptibility of a specimen of very soft iron to reach up to 280, and when mechanical vibrations were applied to the same specimen while under the magnetising force its susceptibility increased to as high a value as 1,600.

One important point must be noted. Any piece of iron, the susceptibility of which is to be determined, must comply in dimensions with the condition of "endlessness" spoken of in para. 133, otherwise the exact magnetising force brought to bear upon it cannot be computed. For instance, from the lower curve in the last figure the susceptibility of that specimen of iron cannot be derived, because the dimensions of the core are such that a demagnetising force of unknown value is acting on it in addition to the force due to the coil.

138. *Further Developments of the Subject.*—Before leaving this subject we shall indicate in what direction the student may experiment with advantage. Besides the acquaintance he will gain with the subject by trying cores of different specimens of iron and steel of different dimensions, he should carry the magnetisation of some specimens through a complete phase or cycle; that is, starting by increasing the current from zero, the ordinary curve of magnetisation rises from 0 (Fig. 120). After carrying this on until the core is fairly saturated, the current is gradually reduced to zero. The curve, as we have seen, will not return to the point of origin by reason of the residual magnetism O A. Now the current in the magnetising coil is reversed, and precisely the same operation repeated—viz., gradual increase of current to fair saturation, and then decrease to zero. This brings us to the point B, the residual magnetism being O B. Now the current is reversed again, and gradually increased until the highest point in the curve is again reached. The core has then been led through a complete cycle of magnetisation. The valuable suggestion made by Mr. Sidney Evershed (*The Electrician*, Nov. 9, 1888) for eliminating the effect of the magnetising coil on the magnetometer, simultaneously with the test, by winding a few turns of the said coil backwards round the magnetometer needle at such a distance as to just neutralise its own effect, should also be taken advantage of. This would allow of seeing at once by the magnetometer deflections when the core approached saturation, and also save the time of plotting two curves.

The core having been led through a cycle of magnetisation in the manner indicated, we have a completely closed curve, the area

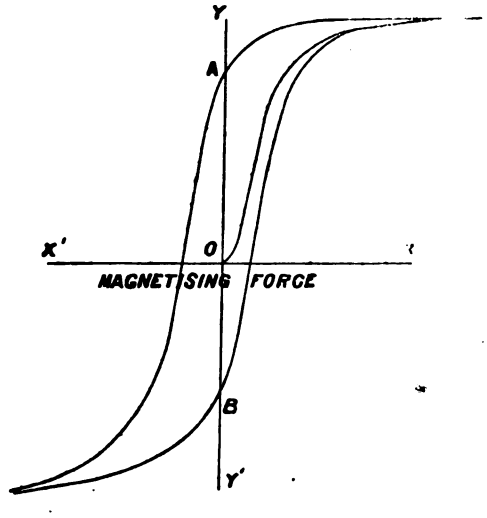

FIG. 120.

enclosed by which is proportional to the amount of work spent per unit volume of iron in conducting it through the cycle. It is evident that the cause of the cyclic curve being of this general shape and enclosing an area is due to the fact that the descending curve does not coincide with the ascending curve, and this latter fact is due to residual magnetism of the iron. In other words, the magnetisation of the iron follows at a distance or "lags behind" the magnetising force acting on it. Prof. Ewing, in a set of exhaustive experiments on this property of iron, carried out some five or six years ago at the Physical Laboratory of the University of Tokio, Japan, calls the phenomenon "*Hysteresis*," from ὑστερέω, to lag behind, and defines it as "the lagging behind of changes in magnetic intensity to changes in magnetising force" ("Researches in Magnetism," *Phil. Trans.*, 1885). In the same Paper we find the pregnant remark, "The existence of residual magnetism, when the field is reduced to zero, is, in fact, only one case of an action which occurs whenever the field is varied in any way, viz., a tendency to persistence of previous magnetic state."

In all electro-magnetic apparatus where the magnetising force is alternating in direction, or where an iron mass moves periodically through alternate fields, the iron undergoes this cyclic change, and we have the phenomenon of hysteresis. In dynamo and motor armatures, and in the cores of "transformers" or "converters" used in distributing electrical energy by the alternate current system, the loss of energy by hysteresis is an important point affecting more or less their working efficiency. It is not within the scope of the present Paper to treat of the above-

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mentioned machines; the student who is pursuing the subject should, however, consult the works already referred to, in addition to which he will find the subject very clearly treated in a "Note on Magnetic Hysteresis," by Dr. J. A. Fleming (*The Electrician*, September 14, 1888). In furtherance of the subject of magnetic susceptibility, a Paper by Mr. R. Shida (*Proc.* Royal Soc., 1883), and one by Mr. A. Tanakadaté on the "Mean Intensity of Magnetism of Soft Iron Bars of Various Lengths in a Uniform Magnetic Field," read before Section A of the Bath meeting of the British Association (*The Electrician*, November 2, 1888), will be found valuable sources of information.

(To be continued.)

LEGAL INTELLIGENCE.

King, Brown and Co. v. The Anglo-American Brush Electric Light Corporation.

The action for reduction of a patent right at the instance of King, Brown and Co., Edinburgh, against the Anglo-American Brush Electric Light Corporation (Limited) was resumed in the Court of Session, Edinburgh, on Thursday, the 29th ult., when the case for the pursuers was continued. Mr. Graham Murray, Mr. Dickson, and Mr. Daniel were counsel for the pursuers; and the Dean of Faculty (Mr. Mackintosh, Q.C.), and Mr. Jameson for the defenders.

WILLIAM AUGUSTUS GORMAN, sole partner of Siebe, Gorman and Co., engineers, London, deposed that the machine, No. 29 of productions, was made in their works in 1876 or the beginning of 1877. His firm was interested in the patent, along with Mr. Varley. So far as he was concerned the patent was gone on with up to the dissolution of his partnership with Mr. Siebe in 1878. Cross-examined: As near as he could say he thought the machine was last used for any purpose, experimental or otherwise, about the end of 1877, a few months after its completion.

EDWARD FRASER MYERS, foreman with Siebe and Gorman, deposed that he constructed the machine, No. 29 of productions, in the beginning of 1877, under the instructions of Mr. Varley. As regarded the electrical arrangement, the machine was the same now as when first made. There was one circuit from the machine to the lamp, and there was a thick and a thin wire coiled round the field-magnets. The magnetic power was much increased the moment the arc was pulled. There was no secrecy about the construction or exhibition of the machine. As regarded the commutator, there was first a wooden foundation, the hub or bush, for insulating purposes. The gunmetal base pieces were permanently fixed to that wooden arrangement, and then there was a steel plate, which could be detached and romoved when it wore. It was attached by four small rivets or screws, fitted from the outside inward, the result being to preserve the cylindrical form of the commutator. He thought there had only once been an alteration of the connections.

Cross-examined: The connection between the wearing segment and the sub-segment performed the functions of both a screw and a rivet. Their idea was that the wearing segment could be removed without disturbing the sub-segment.

FREDERICK JOHN GARNISH, works manager to Siebe and Gorman, gave similar evidence as to the making and working of the machine in 1877.

DUNCAN CARMICHAEL, instrument maker in the employment of James White, optician, Glasgow, said a gentleman had called upon him recently with a copy of Varley's specification, and at his request witness made a model of the field-magnets of the machine there described. At that time he knew nothing whatever about dynamos, or of the difference between shunt, series, and compound winding.

HUGH HOLMES M'TAGGART, apprentice with Brown Brothers and Co., hydraulic engineers, Edinburgh, said he had made the model of a machine from the following instructions given to him by his employer on a piece of paper:—"You will wrap the soft-iron magnets with two insulated wires, one having larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light." He had no knowledge whatever of magnetism or electricity before.

GEORGE B. ANDERSON, apprentice with James White, instrument maker, Glasgow, said he began to study electrical engineering about five weeks ago. On 12th November Mr. Brown called at his workshop and gave him a copy of Varley's specification, from which he made the model produced. Nobody helped him, and he consulted no other book. He knew a little of the first principles of dynamos, but nothing about compound dynamos.

Dr. JOHN HOPKINSON, recalled, said he had opened up Varley's machine, and he found that the commutator consisted of a central boss or hub of wood of cylindrical form, to which were attached segments of brass connected to the wire of the armature. All these segments of brass were attached by means of screws to plates of iron, upon which the collecting brushes were joined together. It would be correct to describe the whole commutator as a "commutator cylindrical in form, consisting of insulating hub or body, to which are attached sub-segments placed in proper electrical connection with the general mechanism in which the commutator is employed, and wearing segments detachably attached."

Cross-examined: *Q.* Are there on this commutator metallic insulating segments such as we have in Brush's commutator?—*A.* There is this slight difference between them—in Varley's commutator the segments serve to form a connection between the two opposite brushes at the time at which the sections of the armature are insulated. In Brush's, the compensating segments insulate both the armature and the brushes from each other.

JAMES SWINBURNE, consulting engineer, and formerly manager of the Swan lamp works in Paris, the Brush-Swan lamp works in America, Hammond's incandescent lamp department, and scientific manager to Crompton and Co., deposed that he had examined the specifications of Haddon and Varley. The invention foreshadowed in Haddon's provisional specification was that of putting wearing segments on to sub-segments of the commutator. In 1878 commutators were very well known. They were arranged in various ways, but most of them had an insulating body on which the segments were placed. With reference to claims 4, 5 and 6, the use of the insulating segment T appeared to have been something for the brushes to rest on that was insulated from the rest of the commutator. The reason electrically for having a particular portion of the revolution where there was insulation between the brush and the armature was, that at that part of the revolution the coil corresponding to the segment of each side was not giving any current, and they did not want to take anything off. There was no disclosure of that in the provisional specification. The provisional specification was co-extensive with claim 2, and there was nothing about claim 4. Witness was present when Varley's machine was opened up, and he agreed with Dr. Hopkinson's description of its commutator. Brush spoke at considerable length of the advantages to be got in the process of electro-plating, but witness did not find in any part of the specification any hint of an anxiety to get a constant potential machine. Series shunt-winding was clearly described in the specification. Assuming a machine to be made in terms of that specification, and wound series shunt as there described, it would not necessarily follow that the machine would be a constant potential machine. *Q.* Is there anything in Brush's specification or drawings to give you the knowledge which is required in order to secure a constant potential machine?—*A.* No. Brush's specification would in some ways mislead. He mentioned in one place that the shunt wire might be larger than the series, or they might be of the same size, and he said the teaser might be wound in two courses. That would be misleading except for very low electromotive force. There was nothing in the drawings to show sufficiently the diameter of the wires and the other conditions necessary to get constant potential. He could hardly imagine there could be any machine which would not lose its field on open circuit with so little shunt as that.—*Q.* Do you find anything as to the mode of winding disclosed in Brush's specification that is not already disclosed in Varley?—*A.* There was nothing disclosed in Brush as to series shunt-winding that was not disclosed in Varley's specification. Varley said he covered the magnets with two wires, and that the one of larger resistance was always closed, and the one of less resistance was used for the electric light. If the one of less resistance were not in series with the electric lamp there would be no particular reason for denoting that as an electric light circuit; neither of them would be an electric light circuit. Varley went on to say that when the electric light circuit was open from any cause the electricity developed passed through the circuit of greater resistance only, and maintained the magnetism of the magnets. That showed that when the electric light circuit was not open electricity did not pass only through that circuit of greater resistance but passed through both the circuits; therefore, the circuit of low resistance must have been in series with the arc light. *Q.* It has been suggested that the method of winding there described might be a method by which there should be separate excitation from different parts of the armature; do you think that is consistent with what you find in the rest of the specification? *A.* It is inconsistent with the whole of the description of the machine in the specification. That description showed that the bobbins of the armature were all connected together in series, and that was inconsistent with a separate part of the armature being used for excitation, and that was also clearly shown in one of the figures. Besides the dynamo, Varley described a sort of semi-incandescent lamp, which he called an arc lamp. Series shunt-winding was very much a desideratum for that lamp as described. [Shown Varley's machine, No. 29 of productions.] Apart from other things, the thick wire was too thick to be connected with a second shunt. *Q.* Can you tell, as matter of fact, from that machine, that it was not used for separate excitation?—*A.* Yes; there is nothing to take the portion of the current off, and all the bobbins are accounted for. The present commutator was exclusive of the idea of working by separate excitation. If he were told as a fact that when that machine was used and when the electric light was burning the magnetism of the machine was more

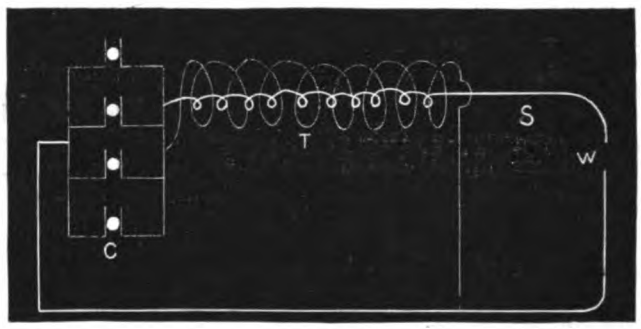

FIG. 1.

The above diagram is taken from the rough sketch made by Mr. Varley in his private note-book. See *The Electrician*, Nov. 30, p. 114.

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largely developed than when the lamp was not burning, that would show clearly that the electric arc was in series with the wire round the field-magnets. If he were also told that when they worked the machine with the lamp on they found that the machine became bound by the magnets pressing upon the armature, that would show the same still more conclusively. He had seen Varley's sketch, which clearly showed series shunt winding. [Fig. 1 is a facsimile of the sketch referred to.]

Cross-examined: *Q.* Between Varley's wearing segments and Brush's wearing segments is there not this difference, that Varley's are fastened on to the other segments by pins, and in Brush's by a peculiarly-shaped screw with a long head?—*A.* The pins in Varley's are screwed at the end, and the only difference is that Brush's have a longer cylindrical head. The rivets in Varley's were a different arrangement fom the screws in Brush when they were put in, but there was not much difference when taken out. He believed that in the Crompton case they submitted to an injunction, and paid £2,000. He had never heard of a series shunt-wound machine before Brush's. *Q.* Is it not the case that Brush's machines show a very much larger resistance in the shunt than in the series winding?—*A.* I cannot say that the drawings show much about resistance at all; they are simply drawings to show the place of the wires. *Q.* Would not machines made with wires of those proportional thicknesses have a tendency to produce constant potential?—*A.* Compared with a series machine he thought a machine made according to the proportion he found existing in these figures would tend towards constant potential; compared with a shunt machine he thought it would not. He would expect to find in a specification instructions by which a skilled workman could find his proportions.—*Q.* Would not a skilled electrical workman find out for himself according to the requirements of the machine he was told to make, and the proportion of the wire to put on?—*A.* It took Brush five years to find out constant potential in this specification, and I must say I have not found it yet. He was not aware that Sir W. Siemens took out a patent for a small shunt-winding machine in 1879; if he did, he must have been very lax, because it had been already described. In Varley's specification if they wound shunt and series so that the resistance would be nearly the same, he thought the machine would heat so much as to destroy the insulation. He had measured the resistances of the armature and field-magnet coils of Varley's machine, and he thought the figures would be about 9 ohms for the armature, about 2 ohms for the large wire coil, and about 10 ohms for the small, and the diameters were, he thought, ·124in. and ·042in.

Re-examined: Constant-potential or compound-wound machines were brought into use by Crompton in the end of 1882 or beginning of 1883. Other makers took them up in 1883 or 1884. The descriptions of the Brush machine in those days gave other modes of securing constant potential, such as automatic regulators worked by little belts.

Re cross-examined: *Q.* Were these automatic regulators brought into use by the British officials of the Anglo-American Brush Company intended to apply to machines in order to get a constant current as contrasted with a constant potential?—*A.* No; the things I think of were for constant potential for incandescent lamps. Crompton paid royalty to the Brush Company for every one of those compound-wound engines he made.

JAMES ALFRED EWING, Professor of Engineering in University College, Dundee, gave evidence as to the commutators described in the two specifications being of a similar character to that given by previous witnesses. With regard to Brush's seventh claim, he found no hint in the specification from beginning to end of his having thought of the desirability of trying to obtain a machine which would work with constant potential. At the date of Brush's patent constant potential was not a special desideratum. Varley's specification clearly described a series-shunt winding. There was also disclosed in Varley's specifications a certain form of lamp for producing an arc light. For that particular lamp series-shunt winding would be a distinct advantage.

Cross-examined: He did not think that an approach to constant electric potential was of any advantage to electro-plating, not even when the articles to be electro-plated were in parallel in the bath. He should prefer a plain shunt machine to a series shunt-wound machine for electro-plating. He did not hear of series-shunt winding till long after Brush had published his patent in this country. He had seen several Brush machines before compound winding for self-regulation became common, and he never saw one of them which was a series shunt-wound machine. The Brush machines which he saw were plain series machines.

Re-examined: If he made a machine according to Brush's specification, and set it to work, the chances were one million to one that he should not get anything like constant potential.

JOHN WALKER, foreman model maker in the Museum of Science and Art, Edinburgh, produced a model which he had made from Varley's specification, at the request of Mr. Brown. He told witness nothing about compound winding.

ANDREW B. BROWN, one of the pursuers, said the description given of his instructions to the four witnesses who had made models for him was perfectly correct. He knew about the action at the instance of the Brush Company against the Orient Steam Navigation Company regarding a machine made by witness. He understood that judgment went against the Orient Company, but his firm declined to have anything to do with the action, and no one connected with the firm had agreed to keep the Orient Company free of expense in that case.

This concluded the case for the pursuers, and the Court adjourned till next day.

FRIDAY.

DEFENDERS' PROOF.

The case for the defenders was opened to-day before Lord Trayner, the first witness called being

SILVANUS P. THOMPSON, B.A., D.Sc., who deposed that he was Principal of the City and Guilds of London Technical College and Professor of Physics in that College. In 1879 the shunt arrangement was not one likely to be known to an ordinary electrical workman, and no machines to his knowledge had been constructed in 1879, or were in practical use. At the date of Haddan's specification, in 1878, the machines which were well known belonged to four classes—permanent-magnet machines, machines excited from a separate source, machines excited in series, and machines excited by a separate but self-contained circuit. That equally applied to the year 1876. [Shown a diagram.] That represented a series-shunt arrangement as described by Haddan. The name witness used for it was the "long-shunt" arrangement. [Shown another diagram.] That represented another series-shunt arrangement described by Haddan, known as the "short-shunt." These were mere modifications one of the other. The effect of the series-shunt arrangement described by Haddan as contrasted with the mere shunt arrangement was this, that when you draw larger current from the machine, the potential instead of rising, as it would do in a mere series machine, will not rise so much; or, in some cases it might remain perfectly steady, or in some cases it might even fall. Comparing it with the shunt arrangement, whereas with the mere shunt arrangement when you draw more current from the machine the potential would fall, in the series-shunt arrangement the potential would either in the one case not fall so much, or in the other case remain firm, or in the other case might even rise. In the series-shunt machine the two opposite tendencies which he had mentioned as affecting that machine tended to counteract one another in every case, and by tending to counteract one another they tended to keep the potential constant. *Q.* In whatever proportion the diameters of the wires are, and in whatever proportions the number of coils of the two wires are, is the joint effect of two wires that each wire to a greater or less extent supplements the other?—*A.* Yes. *Q.* And each wire to a greater or less extent prevents the disadvantages of the other from being felt?—*A.* Undoubtedly. *Q.* In short, do the two compensate one another?—*A.* They do. They did not always accurately compensate, but they tended to compensate one another. That tendency to compensate was a most valuable step in advance. *Q.* Had anything of the kind, to your knowledge, been disclosed or suggested prior to Haddan's patent?—*A.* Not by means of double-winding. There had been various attempts to regulate the strength of the electric current by devices that required moving by the hand—the introduction of additional resistance and the like; but automatic arrangements of this kind depending upon the compensation between the two wires, one in series and one in shunt, was at that date entirely new. Haddan's specification described the series-shunt arrangement accurately and with remarkable detail. The drawings attached to the specification were such as would unquestionably enable any workman who followed them to make a machine which would have the advantages he had described. Referring to the letterpress of Haddan's description, he had no recollection of any passage in which he professed that his machine should produce constant potential. *Q.* Although Haddan does not profess that his machine shall produce constant potential, are you able to say whether, if a machine was constructed according to the description and the drawings, it would, or would not, in fact tend to produce constant potential?—*A.* It does as a matter of fact; I have tried it. The degree of approximation to constant potential depends upon several circumstances, including the speed at which the machine is driven, the proprotions between the coils, their resistance, and the number of turns of wire in the separate windings. He had tried a machine according to Brush's drawings and from Brush's specification, and he found that when used it did approximate in its potential and constancy. The speed at which that machine was driven was 1,250 revolutions per minute, the ordinary speed, and the current that was drawn from it varied from nothing up to 211 amperes. The potential remained very nearly constant. It increased slightly at first, and it fell slightly afterwards. When there was no current drawn from the machine the potential at the terminals was 3·54 volts; when 100 amperes were being drawn it had risen to 3·68 volts; at 125 amperes it had fallen back to the original 3·54 volts; when 150 amperes were drawn it fell to 3·45 volts; and it remained at that with the highest current drawn—211 amperes. He examined the machine to see whether it was in terms of Brush's specification. It was obviously an old machine. He examined a similar machine in February of this year also at Brush's works, and also a machine which he found to correspond with Brush's specification, and the performance of which was almost the same. Series-shunt machines were now very extensively used. They had not superseded all other dynamo machines. *Q.* Has subsequent invention or experience added anything to what Brush mentions in his specification, and if so, what?—*A.* Experience has added this: that where a type of machine has been manufactured, and its qualities are known, you can now calculate beforehand the proper amount, thickness, and so forth, of the two windings to be afterwards wound upon that machine. *Q.* As to the proportions, would it be possible in the specification of a patent to give proportions which would be of material aid to a workman in constructing such a machine?—*A.* I am afraid such instructions would mislead the workman, because he would think there was some fixed proportion. It would be far better if they had given him instructions how to make experiments for the proportions for each machine or each type of machine. *Q.* If Brush had given directions for the proportions in which the coils were to be laid on, would he have given directions that would have been materially valuable to a skilled workman for the purpose he had in view?—*A.* They would have been valuable for a particular type, but would have been misleading if they had been interpreted for all types. *Q.* In your opinion, could Brush have given better directions than he has done?—*A.* At that date I think not because he was ahead of all of us who were working at the theory of the subject. Brush's description left witness in no doubt whatever that he supplied his coils by a bifurcated current. That was absolutely so, because he said "it divides itself between the external circuit and the teaser inversely as their respective resistances." It could not have been more definitely described to an electrician. The armature generated current, which was

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delivered through the commutator to the springs or brushes, and after that it went to a certain place where it bifurcated. For the purpose of electro-plating, Brush's series-shunt machine was a great improvement upon magneto machines and series machines, and possibly machines separately excited from a separate source, so far as it enabled the machine to adjust its operation to the work in the bath. Another advantage was that it was less liable to reverse if the speed dropped than the series machine. With regard to Varley's specification of 1876 he had been referred to the passage on page 8, lines 38 to 49, where Haddan's invention was said to have been anticipated. That passage was not made the subject of any claim. A machine might be made under claim 1; that had nothing whatever to do with that passage. I do not understand the claim to be for the machine at all; it is a principle—cutting out some bobbins. He had considered the description with the specification of the arrangements in the course of which the passage relied on was introduced. There were several electrical absurdities in the course of the description. There is a thing which was electrically absurd on page 6, line 46:—"The force consumed in giving motion to the machine is being converted into magnetism and electricity at the same time, and the magnetism produced is less proportionately as electricity is developed." That was an erroneous notion altogether. The alteration in the magnetism and the fluctuations of the electricity went on simultaneously, and you wish, as a matter of fact, to have the greatest alterations in the one in order to get the greatest development in the other. What was then mentioned as a fault in the existing machines was absolutely the way in which the machines really worked. Varley went on: "My improvement consists in separating the development of electrical and magnetic forces to a considerable extent"—that was a mere consequence of his erroneous notion—"obtaining thereby greatly increased magnetic potential in the bobbins, which at a later stage becomes converted into electricity of a corresponding high potential." That was nonsense, because it was the consequence of an erroneous theory, and was equally an electrical absurdity. He had not met with any electrical absurdities in Brush's specification. Taking the passage in Varley's specification, on p. 8, line 38: "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce electric light," and stopping there that passage was not consistent with a series-shunt arrangement. It was consistent with the use of a shunt, because in shunts, as in a separate-circuit arrangement, part of the electricity developed by the machine was diverted to maintain the magnetism of the magnets, but it was inconsistent with there being a series winding, because the remaining portion does not go round the magnets and produce the electric light. The essential characteristics of series-shunt winding were that the whole of the electricity produced shall travel round the magnets, part through one coil, part through the other coil. These characteristics were negatived by the last part of the sentence he had read. He went on to say, "There were several well-known ways of doing this," and by this witness understood him to mean diverting a part of the electricity developed by the machine to the magnets. The ways of doing this that were well known in 1879 were three varieties of excitation by a separate self-contained circuit. There was the method devised by Wilde, there was another device by Ruhmkorff, and the third method was described by Ladd. In witness's opinion any electrical workman who was told to divide up the electricity of the machines at that date would instantly have thought of Wilde's, because Wilde's machines were, perhaps, the best known at that time. The shunt arrangement would not have been known to the workman. In Wilde's a few of the coils of the armature were separately connected up to a circuit which went round the field-magnets so as to form a separate circuit internal to the machine, the magnetism being developed within the machine, but by a separate part of the machine. Varley in his 1867 patent had described a somewhat similar mode, but with two windings on the field-magnets, as well as on the armature. The two currents came from separate sources. There was no bifurcation. *Q.* In short, the principle of bifurcation was not in 1876 a thing known to any electrical workman?—*A.* I do not think the electrical workman would ever have heard of it. Varley in his specification proceeded:—"The method I prefer is to wrap the soft iron magnets with two insulated wires, one having larger resistance than the other. The circuit of larger resistance was always closed, and the circuit of less resistance was used for the electric light." That differed from Varley's 1867 machine only in one respect. There were two circuits side by side distinct, each going to its own winding; but now the two windings being alike, one had a higher resistance than the other. There was no suggestion of any distinction as to the source of the electricity; it appeared to be exactly as before. There was nothing so far inconsistent with the Wilde arrangement, or the Ladd arrangement, or the Ruhmkorff arrangement, but there was something supplementary to it. The next paragraph in the specification was—"When the electric light is being produced the greater portion of the electricity passes through the circuit of less resistance, which I term the electric-light circuit, in sustaining the magnetism of the magnets and producing the light. When the electric-light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." In witness's opinion, taking the state of electrical knowledge in 1876, that passage would not have conveyed to any ordinary electrical workman the suggestion of series-shunt winding described by Brush, taking that passage as a whole. He thought it would have led him to suppose that these two windings were to be supplied from two separate groups, or portions of groups, of coils on the armature, and that they worked alternately, that the current went from one armature through one winding one way, and that the other current started from the other armature through the other circuit, as in the 1867 machine. The whole description was consistent with the circuit of greater resistance being a circuit complete in itself and separate from the electric-light circuit. It was quite consistent with the division of the electricity being effected in what he had stated was the then usual manner. There was no direction or suggestion whatever in that passage that the division was to be effected by the bifurcation of the original common current. Taking the specification as a whole, or confining himself to any part of it, his opinion was that it did not disclose the series-shunt machine as described by Brush. It was not fitted to suggest to a skilled workman having the knowledge of the period such an arrangement as that of Haddan. In Haddan's arrangement the shunt actually formed a closed circuit within the machine. It was so described and so shown on the drawings. Varley's circuit of greater resistance was taken outside the machine. So taken out of the machine it was taken to work the motor of the lamp. Being so employed, it would not serve the same purpose as Haddan's circuit of greater resistance closed within the machine. It served a different function. Brush warned you specially against the waste of current if the shunt-circuit was not of much higher resistance. Witness did not know any passage in Varley to warn the workman against making the coil of high resistance of nearly equal resistance to the other. If it were merely made higher and not greatly higher the machine would destroy itself. Cromwell Varley's communication to the Royal Society, where there was a reference to a secondary wire or a copper cylinder, did not suggest to him any resemblance to the series-shunt arrangement. He did not see that it had very much bearing upon his evidence as to the passage relied upon on page 8, because in the first place it had nothing to do with the mixed series-shunt winding; and, secondly, this secondary wire or copper cylinder which was to be placed on his magnet acted in a wholly different way. It was not furnished with any of the electricity coming from any armature coil of any kind. It merely acted as a damper. It maintained magnetism in this sense, that it damped fluctuations of the magnetism, and it could do nothing more. He had examined Varley's machine made by Siebe and Gorman. There was nothing in it to show how it was coupled up when it was used. There were an unnecessary number of terminal screws to receive the ends of the wires, and that would indicate beyond all question that it was intended to try coupling up that machine in various ways. *Q.* Could the machine, as you see it, be used as a shunt and series machine, or double shunt or double series?—*A.* It could be used in any of these three ways or more. It could be used as a separately-excited machine; it could be used in every other way he had described except permanent magnets. He had read the passage in Haddan's specification which related to the commutators, and he had also examined the passage in the final specification which referred to the commutators and the claims for the commutators. There was nothing in the commutator claims which appeared to him to go beyond the fair carrying out of the arrangements described in the provisional specification. They referred mainly to making the commutators of easier construction and of more ready repair after wear. He had examined the commutator on Varley's machine; but he could not see that it anticipated Haddan's commutator. The wearing segments did not seem to be detachably fastened, so as to allow of repair in the same way.

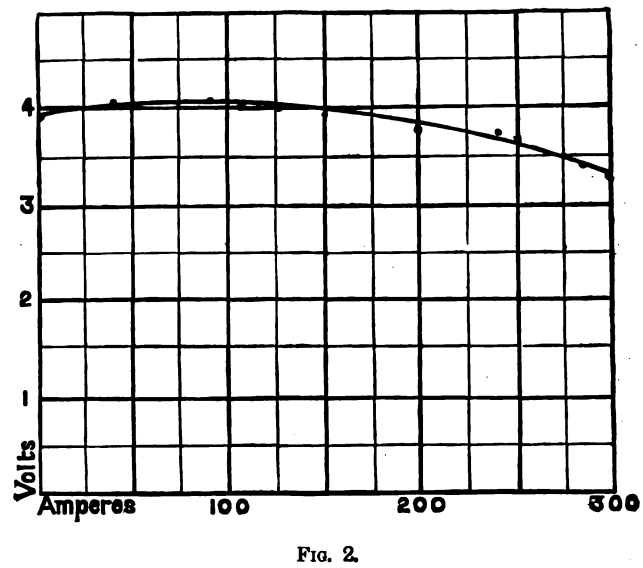

FIG. 2.

Cross-examined by Mr. MURRAY: Siemens' communication in 1880 investigated the utility of shunt winding, treating it as an old thing. Clark's specification was a disclosure of pure shunt, and at a date previous to Brush. It gave a hint that pure shunt would be very useful in electro-metallurgy. It was the case that in Brush's patent, as originally framed, he had a claim which claimed pure shunt, and one of the methods he disclosed in the description of his machine was pure shunt. That was afterwards disclaimed. He imagined that Varley would know of the existence of shunt at the date of his patent. [Shown No. 40 of productions.] So far as that drawing went, it indicated a series-shunt arrangement. *Q.* Do you take it that the object of Brush's invention was to give a constant potential?—*A.* He never says so. *Q.* On the other hand, he does say that his object is to secure a permanent field?—*A.* One of his objects. *Q.* And if he has another he does not say what it is?—*A.* Yes, he indicates it distinctly; he says it was to enable his machine to do either a large or a small amount of work. He should have expected much more specific instructions than were given in Brush's specification if the patent had been one for constant potential. In witness's view there was still

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potential matter left for the getting of constant potential after Brush had made his discovery of compound winding; and further application of compound winding to attain constant potential was patentable after Brush's patent. Crompton, among others, took out patents. Being shown *The Electrician* of date Friday, 2nd Oct., 1885, with supplement called the *Exhibition Record*, he said there was a diagram there of a Brush electro-plating dynamo (Fig. 2). That diagram showed the working of one of the old Brush machines as regarded constancy of potential. *Q.* Is it very bad? *A.* It is a great deal better than anything before that time; it is nothing like what constant potential is now. It tends to it, but it is not good enough. There was nearly 20 per cent. of variation upon it. It was a matter of opinion whether pure shunt was better for the purpose of electro-plating than series shunt. With series shunt it was possible that the polarity of the magnets might become reversed, but not probable; with pure shunt it was impossible. In 1878 he did not know of any case where the incandescent light was a proved success. He believed the difficulty was to discover a perfectly suitable lamp. That came about by degrees in 1878 and 1879, and it was introduced commercially in 1881. As soon as it did come in, that made it most desirable to have constant potential. As a matter of fact, a great many methods were tried for ensuring constant potential. The Brush Company in England proposed several kinds of regulators for the regulation of the dynamos, so as to ensure constant potential. Allan's patent automatic regulator was about 1883. Most of these devices were prior to the discovery of those conditions of proportionate resistance, and so on, which they now knew, and which ensured constant potential in a series-shunt machine. It would be quite useless to have an extraneous device when you could secure it in the machine itself by simply wrapping the wires in the proper way.

This concluded the evidence for the day, and further hearing of the proof was adjourned till Wednesday.

(TELEGRAM FROM OUR CORRESPONDENT.)

EDINBURGH, THURSDAY EVENING.

Evidence for defenders concluded to-day. The cross-examination of Prof. Pirie was completed; and after hearing the evidence of Mr. Alfred Hicks, Sir. Wm. Thompson, Mr. W. H. Preece, and Mr. P. Sellon, the Court rose. The hearing of the case will be resumed in January, after the evidence of Mr. Brush, taken on commission, has been received.

[A full report of the proceedings on Wednesday and Thursday will appear in our next issue.]

Edison and Swan Electric Light Company v. Holland and Others.

THE CASE ON APPEAL.

The hearing of the plaintiffs' appeal against the judgment of Mr. Justice Kay, finding that the patent of Edison's incandescent lamp was not protected because the method of working was insufficiently set forth in the specification, was commenced on Saturday in the Court of Appeal, before Lords Justices Cotton, Lindley, and Bowen. Sir William Grove, the distinguished scientist and inventor, and late a Justice of the High Court, also occupied a seat on the Bench. The counsel for the plaintiffs were the Attorney-General (Sir Richard Webster), Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Bremner; the defendants were represented by Sir Horace Davey, Q.C., Mr. Finlay, Q.C., and Mr. J. C. Graham.

The ATTORNEY-GENERAL said he appeared on behalf of the appellants in respect of the infringement of two patents vested in the Swan United Electric Light Company, and known as the Edison patent and the Cheesbrough patent. Both patents were before the Court in the case of "Edison v. Woodhouse and Rawson." The Edison patent related to the mode of construction of an incandescent lamp; the Cheesbrough patent related to the method of preparing in a better way the conductor to be used in incandescent electric lighting—that was to say, the carbon. Mr. Justice Kay found for the plaintiffs in respect of the Cheesbrough patent, relating to the improved method of conducting the material of the conductor, and he found on a number of issues for the plaintiffs in the Edison patent; but he found one matter against them, namely, the deficiency in the specification as to the method of working. There was no appeal against Mr. Justice Kay's decision with respect to the Cheesbrough patent; the judgment for the plaintiff, the injunction and the consequences stood as in Mr. Justice Kay's judgment. This appeal was by the plaintiffs against that part of the judgment of Mr. Justice Kay which found for the defendants on the ground that objection could be taken to the Edison patent. In the Court below the case lasted for twenty-three days, but on appeal he thought it need not last a quarter of that time; but it was essential in the first place to put before their lordships a general outline of the case. Amongst the issues which were found for the plaintiffs was that Mr. Edison was the true and first inventor, the combination which he described was new, and that the defendants had infringed; but at this late day in the life of this patent the learned judge found that there was not sufficient information given in the specification to enable a competent workman to construct this combination. There was one other point of considerable importance which was to a certain extent interwoven with the one to which he had just referred. Mr. Justice Kay applied to this specification a test which, so far as his reading went, was absolutely new, and, as he should submit, contrary to the principle of the patent law; that was the test of commercial utility as distinguished from utility generally. He would in the course of the case have occasion to call atention to legal authority to show that the test which Mr. Justice Kay applied in construing this specification was incorrect in law, and not in accordance with decisions so far as that question ever had been dealt with. Indicating the line of argument he proposed to follow, the Attorney-General said he proposed to state as fairly as he could what was the existing state of knowledge at the date of the patent, as he stated it before Mr. Justice Butt in the case of "Woodhouse and Rawson," and before the Court of Appeal in that case, and before Mr. Justice Kay in the present case. Having done that he proposed to call attention to the specification of Mr. Edison, and to see what was the invention on the face of the specification. He then proposed to take the judgment of Mr. Justice Kay, and to show (with very great submission to his opinion) the errors into which the plaintiffs alleged that he had fallen, and then, with the assistance of his learned friends, to bring before their lordships' attention so much of the evidence as had a direct bearing on the issue raised by Mr. Justice Kay's judgment. One observation suggested itself on the threshold of the attack which he was about to make upon the finding in favour of the defendants. The experiments upon which the sufficiency of this specification was attacked were substantially —and he might say almost without exception—experiments made after the trial of the action had been actually commenced. He would be able to demonstrate that the defence as to the insufficiency of the specification was a complete afterthought, the experiments upon which the attack was made having been made after the principal witness for the plaintiffs had been examined. The plaintiffs called rebutting evidence, and in consequence of that rebutting evidence, which was of a most remarkable character, Mr. Justice Kay said he would have the experiments repeated before an independent referee, and Prof. Stokes, of the University of Cambridge, was chosen as referee, and made a report to the Court, stating that, without exception, on every-one of the matters of attack which was brought against Mr. Edison's specification the witnesses for the defence were absolutely and entirely wrong. He would show to their lordships that the attacks which were made by expert witnesses to endeavour to break this patent down after a life of ten years on the ground of the insufficiency of the specification were, according to Prof. Stokes's report without foundation. Nay, more, when he came to deal with the judgment of Mr. Justice Kay, he thought he would be able to show their lordships that there was, possibly owing to the length of the case, and possibly owing to the cause which he would rather not refer to at present, but which he might have to say a word or two about later on, a forgetfulness in the mind of Mr. Justice Kay as to certain most remarkable things that had been proved. The Attorney-General then proceeded to deal with the state of knowledge at the date of Edison's patent, which was dated 10th November, 1879. In this case they had nothing to do with the power which produced electricity. They had nothing to do with the sources from which electricity was derived or supplied. [The leading features of the incandescent lamp were then described at some length]. The earliest incandescent lamps were made in the year 1845. From 1845 down to 1879 these attempts went on, the experiments being revived from time to time, without any success at all, or rather without any success which led to the development of incandescent lighting. In the specification of 1879 Mr. Edison no doubt did disclose things which formed a part of Mr. Swan's patent. Mr. Lane-Fox had previously discovered that high-resistance lamps were more likely to succeed than lamps of low-resistance, and he devised a means of mixing up non-conducting material with conducting material, as for instance, asbestos with carbon, but the idea of a carbon filament wholly escaped him. So far as prior knowledge was concerned this was about the condition of makers; it was known long before 1879 that you could raise to incandescence conductors of various kinds; known long before 1879 that carbon was a suitable conductor; known that high-resistance lamps were likely to be of more advantage for the purpose of incandescent lighting as compared with lamps of low-resistance; known that a vacuum was the proper condition for the success of these lamps; but it had occurred to no one that a simple carbon in the shape of a filament was sufficiently strong to fulfil the conditions. Therefore, when Mr. Edison grasped the idea and enunciated it in a form capable of being carried into practical effect, a step—a marvellous step—was made in connection with the invention. For forty years people were trying to overcome the difficulties of electric lighting almost in the same way, and Mr. Lane-Fox, one of the most remarkable names connected with the history of electric lighting, and one of its most remarkable prophets, tried his hardest to perfect an incandescent lamp by strengthening the bridge by the use of non-conducting materials, because he thought conducting materials had two effects—those that were of sufficiently high resistance were too weak to stand the strain; those that were strong enough were bad conductors. Then there was the discovery of Mr. Justice Grove with reference to platinum wires; but though platinum was a good conductor the current required was so large that the glass was cracked by the heat used to raise the platinum wire to incandescence. A notable name that would figure in the case was that of Mr. Joseph Wilson Swan, to whose indomitable perseverance the present perfection of the lamp was due. Having worked at the matter for fifteen years, in the autumn of 1878 Mr. Swan got the nearest approach that was ever made to the Edison lamp or the subsequent Swan lamp prior to the publication of Edison's specification. [A Swan lamp of 1878 was here handed up to the Court.] He should state, to be accurate, that the lamp was made by Stearn, but it had always been called Swan's lamp, and was really the outcome of mutual experiments made by Swan and Stearn. It consisted of a globe of glass, with platinum leading wires, and of a pencil or stick of carbon, the history of which was not known when the case of "Edison v. Woodhouse and Rawson" was originally before Mr. Justice Butt, but had since, fortunately, been fully ascertained from Mr. Swan himself. That lamp was made in December, 1878, but although Mr. Swan and Mr. Stearn had worked the matter out theoretically and, to a certain extent, practically, the result they arrived at positively led people astray, and it led even Swan and Stearn themselves in the wrong direction. The most powerful argument that could be adduced in favour of Mr. Edison was the evidence of the men who were supposed at that particular time to have anticipated Mr. Edison's invention, not publicly, but in their own minds, and it was now fully recognised and ad-

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mitted that Edison had anticipated Swan in this discovery. This was clear upon correspondence which had taken place at the time, which had been accidentally preserved, and was now in evidence, and the fact would be plain beyond all doubt. Although the experiments of Swan and Stearn had been a great success, and although it was admitted they had come close to Edison's invention, yet it led Swan and Stearn completely wrong, so little did anybody think that the solution lay in the direction of a filament of carbon; so little did they know its flexibility, its resiliency, and other characteristics. After the supposed anticipation of Edison, through the year 1879 Stearn and Swan were experimenting with a view to a patent, and the defendants attempted to set up the case that they produced a lamp with a carbonised thread which was the same thing as Edison described. In the summer of that year, said the defendants, Mr. Swan showed to a number of people carbonised thread lamps, which were working to the number of hundreds at Newcastle; but Mr. Justice Kay had found for the plaintiffs that, even if such evidence were true, any such attempts were wholly experimental. As a matter of fact, it could be shown, if necessary, that these witnesses were misstating the time, and that no thread lamp was ever made by Swan until January, 1880, a date fixed clearly by the fact of a fire at Mr. Swan's works, by which everything was burned down, so that he had to start *de novo*. But besides this, there was the statement of Messrs. Swan and Stearn themselves, that they never did make a thread lamp until after the publication of Edison's specification, or ever even tried to carbonise thread. The defendant relied somewhat upon an article in *Electrotechnische Rundschau*, but this was admittedly written with a view to minimising the value in Germany of Edison's invention. Of course, if the defendant could prove publication by Swan prior to 1879, he must absolutely succeed, but both Swan and Stearn stated that the thread lamp of Swan was not made until the year 1880. That point was of the gravest importance. As a matter of fact, nothing nearer to Edison's lamp than Swan's lamp of 1878 was ever published. Swan and Stearn both failed to realise that they might make the carbon very much smaller than it was in the lamp of 1878; they still thought they must have a strong and relatively massive carbon conductor, and they were working in the direction of strengthening and thickening the carbon conductor instead of thinning it and making it filamentary. The resistance of a lamp varied in proportion of the length to the width of the cross-section; with a given cross-section the longer the conductor the higher the resistance, or, in other words, it required more electricity to raise it to incandescence. The resistance, therefore, depended not only on the width of the cross-section, but upon the length of the conductor used. The Attorney-General then called attention to a number of lamps made by Messrs. Swan and Stearn, as to which he observed that they formed an interesting museum record of the steps of invention. But in all these lamps they were trying different forms of thicker and stiffer carbons. What was the consequence? They immediately got a much higher current of electricity and more heat in the lamp. In all those cases coils of platinum wire in the bottom of the lamps might be noticed, being placed there for the purpose of getting rid of the heat. The carbons were of different forms, one being like a horseshoe, but in one and all some method was adopted of getting rid of the heat by placing a good deal of metal in the lower part of the lamp, with a view that the necessarily high current should be diffused by radiation or conduction through the platinum and the glass, and so to the outer air, so getting over the difficulty of the cracking the glass. It never entered into the minds of Swan and Stearn, any more than it did into the minds of the distinguished men who preceded them, that they should experiment in the direction of relying upon carbon in a filamentary shape, that the problem was to be solved, and solved most effectively, by the utilisation of a filament of carbon, without any additional material to strengthen it, but that it would have sufficient resiliency, sufficient stability, and strength to do the work. It was no exaggeration to say that every single effective incandescent lamp, of which there had been hundreds since the date of Mr. Edison's specification, might be in terms described in the words of Edison's specification, and, indeed, Stearn wrote to Swan before the specification came over, "If Edison means carbon, we are anticipated." That statement was in black and white, and was of itself quite sufficient to dispose of the idea that Swan had already made the lamp in 1879. Coming to the specification of 10th November, 1879, Sir Richard Webster said he proposed to read it with two objects, firstly, to describe what Edison described as his invention, and, secondly, to bring prominently before their lordships' minds the point upon which Mr. Justice Kay had thought there was not sufficient description to enable the work to be done, that being the only issue which had been found against the plaintiffs.

LORD JUSTICE LINDLEY: I suppose in this appeal they rely upon anticipation, or have they given that up?

The ATTORNEY-GENERAL said that his learned friends had given nothing up, and he had never known them to give up anything that was arguable, or even after it had ceased to be arguable. Beyond the fact that Edison did not know accurately everything that had been done in England, the specification would be found to be not an incorrect summary of the state of knowledge at the time. Edison was not quite aware of what had been done in some respects in England. One objection taken against the specification was that the words "properly carbonised" did not convey sufficient information to enable persons to carbonise, but there was not the slightest foundation for saying that the term was not perfectly understood and known by persons having to do with the carbonisation of articles. The description of the filaments as "fibrous vegetable substances coiled" as a description of the most successful electric lamps was applicable to this day, and except in so far as they differed in construction they answered exactly to the description which Edison had enunciated in his specification. Then Edison went on to say, "I have discovered that carbon filaments may be made by a combination of tar and lampblack, the latter being previously ignited in a closed crucible for several hours, afterwards moistened and kneaded until it assumes the consistency of thick putty." That was stated by the defendants not to convey sufficient information to enable a person to do it. The process also was said to be impossible and absurd, and so bad was the specification said to be by some of the defendants' witnesses that they had never tried it. Others said they had tried it, and had failed to do it. But he could show that it was done by boys and girls in the most ordinary and common way, and without the slightest attempt at skill or scientific construction. Everything in the specification had been shown to produce a useful lamp. Then it was said that the making of filaments in this way could only be done by a trick, as the ignition would burn the whole thing up, but it was proved to be possible by the referee appointed by Mr. Justice Kay. But when Mr. Justice Kay came to deal with the matter, he disregarded everything that the referee had said with regard to its feasibility or practicability. The specification also said that small pieces of this substance might be rolled out to the size of $\frac{7}{1000}$in. One witness said it was impossible to get a size less than half a millimetre, and that it could not be carbonised, as it would all be burnt up in ash, but it was proved by plaintiffs' witnesses that hundreds of filaments as thin and thinner than this were made by a boy, and carbonised afterwards without difficulty. Prof. Dewar also did it; but this was disregarded by Mr. Justice Kay when he came to deal with the matter. He would ask their lordships to watch most narrowly the point of attack made for the first time in this case by the evidence of people who had never tried the process until after the case began, and until after the witnesses for the plaintiffs had given their evidence, and to contrast it with what had actually been done by persons who had nothing but the instructions of the specification to go on. It was also alleged for the defendant that this carbon wire could not be rolled out at all. Then said Mr. Edison, "The same may be coated with a non-conducting non-carbonisable substance and wound on a bobbin"—the object of the coating and winding upon some such material as a pipe-stem being to keep the coils separate—"and carbonised in a close chamber by subjecting it to a high heat;" the material, after carbonising, retaining its form. Filaments in accordance with the various processes were actually made in court or in a chamber adjoining, under the very eyes of the learned judge. When he came to deal with the evidence of the defendants' witnesses, he would say, unhesitatingly, that they failed because they did not take pains to succeed. They were found out by Prof. Stokes. They tried to carbonise in an unsuitable crucible not impervious to water, and consequently not impervious to air. It all appeared upon the report of Prof. Stokes. With regard to carbonisation, the thing was said to be absurd and impossible, but Prof. Stokes never found a failure, and when the defendants' witnesses failed the cause of their failure was pointed out to them at once.

Proceeding with the specification, the Attorney-General pointed out that a modification of the carbon by an admixture of powdered camphor or oxide of zinc was provided for, but, according to the defendants, they were said to be things which could not be used, but every one of the lamps made in accordance with Edison's specification fulfilled the conditions of an incandescent lamp subject to one condition, viz., the length of time during which the lamps were burnt. He challenged his learned friends who represented the defendants, when they came to deal with Prof. Stokes's report concerning the process for the formation of the thread or fibre, to show that it required anything more than ordinary workmanlike knowledge.

Proceeding to speak of the grounds on which it was said that it was impossible to carbonise these filaments properly, the Attorney-General said there were several methods of carbonising known, such as packing the article to be carbonised with sand or powdered charcoal, but according to Mr. Edison's process they were not surrounded with anything at all, but simply placed in a closed chamber; but the defendants' witnesses asserted in the most recklessly positive manner, and upon one experiment only, that such a method of carbonisation was impossible. To carbonise these filaments with sand was, they said, ridiculous, and could not possibly succeed; and people did not know that they ought to carbonise with powdered charcoal. In reply to that it was shown by contemporaneous literature that carbonising with powdered charcoal was perfectly well known, and the admissions of the defendants' witnesses practically went to the same extent.

LORD JUSTICE BOWEN: What is the object of surrounding with sand and powdered charcoal?

The ATTORNEY-GENERAL said it was to prevent the oxygen which might be evolved doing combustion work in the chamber. Oxygen might get in from the outside if the chamber were not properly closed, or might be evolved from the material itself; it was to prevent the oxygen burning up the thing which was to be carbonised. Prof. Stokes did not find a sign of failure, both sand and powdered charcoal being used and also a material called kaoline. Yet, in the face of all this, Mr. Justice Kay said the patent was bad because there were not sufficient instructions with regard to carbonisation. It was admitted by the defendants that carbonisation by powdered charcoal was known; but it was contended that there was not in the specification sufficient indication to the workman that he ought to use it. He did not hesitate to say that the attacks made upon the specification were unworthy attacks, and made by people who had not attempted to carry it out, as he would demonstrate upon the evidence itself. How was it that gentlemen like Prof. Crookes, Prof. Silvanus Thompson, and others failed? Prof. Stokes discovered that it was because they used a crucible which would admit the air. It was really almost impossible to believe that scientific gentlemen wishing to inform the Court should have taken so little pains as these gentlemen did. The learned council then said he would proceed to deal with the enunciations of the objections to this patent put forward by the witness, and was engaged in dealing with the evidence of Prof. Crookes when the Court adjourned until Monday.

MONDAY, DEC. 3.

The ATTORNEY-GENERAL resumed his address on behalf of the plaintiffs. Continuing to speak of the evidence of Prof. Crookes, he

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pointed out that Prof. Crookes, amongst other things, objected that the platinum wires would become porous. This, he contended, was an unfair comment on the specification, as it was pointed out in that document that the platinum wires did not go through the glass at all, but were clamped on to the leading wires, which did go through the glass. With regard to the directions as to the use of powdered camphor and oxide of zinc, and the coating with a non-conducting carbonisable material, Prof. Crookes said that these were things which could not be carried out. He was particularly severe as to the powdered camphor and oxide of zinc, which he described as hopelessly misleading directions. Mr. Edison's specification claimed for any fibrous vegetable substance which would leave a carbon residue after heating in a closed chamber. That description was true of every single effective lamp which had ever been used, and it was proved by the evidence of Mr. Swan that what would be a matter of years before Mr. Edison's specification, became a matter of weeks after its publication. It was elicited from the defendants' witnesses that as far as the essential experiments of the Edison combination were concerned, it was a combination which nobody before Mr. Edison had described. The Attorney-General then went on to speak of what occurred before Prof. Stokes, when the defendants again alleged everything to be an impossibility, and required everything to be done over again.

LORD JUSTICE COTTON: They fought hard (laughter).

The ATTORNEY-GENERAL said that the Anglo-American Brush Electric Light Company were manufacturers of these lamps, and no doubt tried everything in their own works.

LORD JUSTICE COTTON: Are the Brush party in attendance?

The ATTORNEY-GENERAL: The Brush Company are defendants. The Brush Company came in as third parties, and defended the action, as having made these lamps. The Attorney-General then proceeded to read the report of Prof. Stokes,* observing that it constituted a very strong commentary on scientific evidence which was being given for the purposes of a case, as compared with scientific evidence which was being given for the purpose of ascertaining the truth. It was impossible in the face of this report to believe the evidence of the defendants' witnesses as to the impossibility of carrying out this process.

LORD JUSTICE LINDLEY: What is the idea in the oxide of zinc?

The ATTORNEY-GENERAL: It was thought it made the material more porous, and gave it greater volume without greater conductivity. The resistance would be the same, but the substance of the filament would be bigger. Mr. Edison's idea was that it would have some effect on the illumination.

In answer to LORD JUSTICE BOWEN,

The ATTORNEY-GENERAL said that one thousand hours was now considered to be the fair life of a lamp, but some of the lamps would, he believed, run for years. A good deal depended upon the stability of the engines running. Experiments were continually being made with a view to making the carbon more lasting. Mr. Swan endeavoured to parchmentise the carbon by removing the cellular development. The earlier lamps ran for perhaps only 150 hours, but that did not affect the validity of the patent; nothing like it had ever been done before. The invention of the filament was, he thought, the most extraordinary step which had ever been made in the history of invention. It was a question of novelty, but that was a question as to which in the previous appeal of Edison *v.* Woodhouse and Rawson.

LORD JUSTICE BOWEN: What is the crucible made of?

The ATTORNEY-GENERAL said it was a plumbago crucible.

Mr. FINLAY said that an ordinary earthenware crucible had also been used.

The ATTORNEY-GENERAL said that no chemist who attempted to carbonise under this specification in a porous crucible could have expected anything but failure, because where the air got in combustion, as distinguished from carbonisation, must take place. Prof. Stokes' report proved to be unfounded and without solid reason every one of the objections taken by the defendants in the course of the case. That which the defendants said never could be done, and was an impossibility, was done in the most ordinary way of carrying out the directions of the specification. There was not one single thing to indicate that in doing that which Prof. Stokes saw done any technical or scientific knowledge, beyond that of an ordinary workman taking the instructions of the specification, was required.

In the course of the trial an admission of an important character was made. That admission was as follows:—"Counsel for all parties admit that running on the pumps or flashing or running on the pumps will materially improve the life of the lamps made at Ponder's End before Prof. Stokes." Flashing was a method of driving out occluded gases well known to Cheesborough and Edison; but the lamps which were tried by Prof. Stokes were tried without any of these improvements having been imposed upon them. The Attorney-General then proceeded to deal with the table of lamps. The lamps made with filaments carbonised in charcoal were unbroken after 30 hours, or five or six working days. This might be thought to be not a long period, but it must be remembered that previous to the specification of Mr. Edison no lamp was known which had any life at all. Lamps with filaments carbonised in sand remained unbroken for upwards of 60 hours. The kaoline filaments were unbroken after 30 to 34 hours' use, and in the case of those with which the zinc oxide was mixed they were unbroken after 40 hours. This was the first time this combination had ever been described, and those lamps were being run under what he might call the dry inexperience of the specification. It could not be contended that because a workman said he could make an improved filament that that was not an infringement. If it were so no lamp could be infringed after it had been improved. In one patent case that was heard before Sir George Jessel the article which was the immediate subject of the patent had never been made at all, because it was shown directly that it could be improved; but the patent still held good and the improvements came under the patent. It was also urged for the defendants that this was a process by which nothing useful could be made; but the lamp was, as a matter of fact, still in use. The Attorney-General went on to read the judgment of Mr. Justice Kay. His commentary upon that judgment was that his lordship delivered it without having in his mind the issues of fact on which the plaintiffs relied. Referring to the comment of the learned judge as to the number of kinds of carbon which could be used, the Attorney-General said that was only an indication of the generality of the invention, which would not at all invalidate it. The various forms of filamentary carbon were all equally good. In the language of Lord Cairns, Mr. Edison in his invention introduced a new integer—that was the carbon filament. With reference to the manufacture of hairpin carbons, the Attorney-General pointed out that Mr. Swan said he had never succeeded at all with a hairpin carbon.

The Court adjourned until the following day.

TUESDAY, DECEMBER 4.

The ATTORNEY-GENERAL, continuing to deal with the judgment of Mr. Justice Kay, said that though the point taken by Mr. Justice Kay was that, having regard to the smallness of the invention, the specification did not give sufficient information as to how the carbon filaments were to be prepared, the plaintiffs contended that it was the use of the carbon filament itself which constituted the new discovery.

LORD JUSTICE COTTON: We all think this was covered by the previous decision, unless the other side can induce us to change our opinion.

The ATTORNEY-GENERAL said the defendants, relying also upon anticipation, called a Mr. Heaviside and another gentleman, whose name he did not recollect, who deposed that in September, 1879, they saw thread lamps or horse-shoe lamps burning in Swan's factory. If that was so that was direct anticipation. They also said these lamps were being run from a gas engine. But it was proved by the evidence of Stearn and Swan that the apparatus which ran those lamps was not put up until 1880, and that Swan and Stearn never made one of those lamps at all until after the fire, which occurred in January, 1880.

LORD JUSTICE LINDLEY thought there was evidently an error of date.

The ATTORNEY-GENERAL said it so happened that Swan had kept Stearn's letters, though Stearn had not kept Swan's letters, because nobody thought the matter would be of any importance. Stearn was a bank manager, and entered into these experiments from a love of electricity. These letters were produced in evidence, amongst them being a letter of Stearn's as late as 1st November, 1879, and one of December, 1879, after the date of the patent, with actual pictures in it of the last development of the lamps that they were then making. As a matter of fact, the first hairpin lamp was mounted by Stearn on 26th November, 1879.

LORD JUSTICE BOWEN: How was the hairpin made?

The ATTORNEY-GENERAL: It was got from Carré; nobody knew how it was made.

LORD JUSTICE BOWEN: You do not know now how it was made.

The ATTORNEY-GENERAL said they did not know now how it was made. It was of about the cross-section of Swan's lamp of 1878; but Swan never made a successful hairpin lamp at all. He submitted that there had been a mistake as to the date, and that the defendants' witnesses really saw in the summer of 1880 what they deposed to having seen in the summer of 1879. He did not feel justified in bringing to their lordships' attention the evidence upon the point which bore upon novelty, but he would give his learned friends notice, in the event of their raising the question of novelty, that he would submit in reply that it showed that the specification was sufficient. If Mr. Justice Kay was right in saying that Edison did nothing to differentiate the Swan lamp of 1878 from that which he was describing in his specification, the answer was that the differentiation was the enunciation of a proposition which indicated absolute success as distinguished from previous failures, and it was not necessary or even proper for a man to go into a detailed method of how he would manufacture his various carbons when he was dealing with the class of filamentary carbons, any one of which would produce an effective lamp; and an effective lamp having been produced the problem is solved. He would ask their lordships to say that if there were brought to bear upon the specification reasonable knowledge and skill, and an intention to work it fairly, the specification was amply sufficient to make this new combination which was described by Mr. Edison. The defendants never said in any part of their case that this was a matter in which direction was required to be given. That was not their case at all. They never took the point which was taken by Lord Justice Lindley, that this work could be done if a proper kind of crucible were adopted. What they said was that it could not be done at all.

LORD JUSTICE BOWEN: That is very true, but the greater includes the less.

The ATTORNEY-GENERAL said he quite agreed that the greater included the less, but his point was that although people knew how to make these filaments, nobody had any idea that this tender thing, which would break in one's fingers if one were not careful, was sufficient to bear the strain of being heated for hundreds and thousands of hours. The people who made the infringing lamps knew what were the practical difficulties of making these filaments, and it could not be suggested that anything depended upon the absence of directions in the specification. What the defendants said was, it cannot be done. More than one of the witnesses said the thing was so absurd they had not even tried it. He would ask their lordships to consider upon this evidence that the process was one which could be carried out. The particular matters as to which the serious attack upon the specification was made would be found on consideration of Prof. Crookes's report not to have been well founded. Going categorically

* See *The Electrician*, July 6th, 1888, p. 269.

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through the objections taken on behalf of the defendants, it would be found that the things which they said were of no use produced effective working lamps which were to-day perfectly useful, subject only to this one criticism, that they did not last so long and could not be made so cheaply as the newer lamps, in which improved methods of making the carbon had been adopted. If it could be shown that the success of these newer lamps depended upon a departure from Edison's combination, he admitted that his difficulties would be great indeed; but the mere fact of lamps having been improved could not prevent the patentee from having the benefit of the combination which he had described.

Mr. MOULTON proceeded to address the Court.

LORD JUSTICE COTTON: The point upon which we are most anxious to hear you is as to what was the state of knowledge as to carbonisation previous to 1879.

Mr. MOULTON said that carbonisation was a well-known term, and a term denoting a well-known operation producing a well-known result. It meant the exposing of any vegetable matter or any wood to a great heat without letting oxygen get to it. The process which went on was called destructive distillation by some people and carbonisation by others.

LORD JUSTICE LINDLEY: It is roasting out of air.

Mr. MOULTON: It is roasting out of air. These woods were composed largely of hydrogen and carbon. The gaseous matter was driven off and the carbon residue was left. Carbonisation took place in gasworks; the gases being driven off the carbon remained. This was a case where those working at the specification would succeed if they carried out the directions. Nobody suggested that by carbonising a result would be obtained which would not succeed in the lamp. Where such a process as carbonisation was spoken of in a specification it was the duty of persons working according to the specification to use the existing knowledge of the world in regard to that process. If that had been done in this case there could have been no failure. Take, for instance, the process of packing with charcoal. There was no question about the directions as to that process being abundantly sufficient. The absurdity of using a crucible for carbonisation which was porous to furnace gases Mr. Moulton illustrated by saying it was equivalent to corking a cracked bottle.

LORD JUSTICE BOWEN said that if the direction to properly carbonise was sufficient for the ordinary workman the question arose as to what degree of knowledge was to be expected in the ordinary workman. Was he to be a chemist?

Mr. MOULTON said his contention was that it was the duty of the "ordinary workman," whether chemist or not, to make himself acquainted with existing knowledge as to carbonisation. He must, of course, be a man of sufficient knowledge to do the work; he must not be an uninstructed workman. He need not be a man of sufficient capacity to convert an imperfect description into a perfect one; but he should be abreast of the knowledge of the world in regard to the process described. A patent was an invention published to the world, but the publication must, of course, be in plain terms. If it was published in conundrums, or in such technical language that it could not be understood, publication could not be said to have taken place. There was no ground for saying that a person with a willing mind could not have made carbon filaments in accordance with the specification of 1879.

The sitting was largely occupied with reading and commenting upon the evidence, and an adjournment was made until Thursday afternoon.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *November 24th*, 1888.

In spite of the lateness of the season for such work, there has been, and still is, great activity in electrical railway circles in this country. The fact is, the motor companies are so loaded up with contracts that they cannot possibly execute them without a tremendous display of energy in road construction, and the running of their factories at full blast. This week the Thomson-Houston Company, for example, has made public some interesting details with regard to new roads which it has in hand at Wichita, Kan.; Topeka, Kan.; Des Moines, Ia.; Seattle, W.T.; Omaha, Neb.; Cleveland and Alliance, O.; Louisville, Ky.; Danville, Va.; Syracuse, N.Y.; Boston, Mass.: Ansonia, Ct.; Bangor, Me.; and Scranton, Pa. I understand that the company has further contracts, but it will be admitted that these in themselves are enough to keep any concern busy, especially when most of the roads are required to start before the snow flies. The Omaha road, which has already been put in operation, with 16 motor cars and 16 plain passenger cars, is unique in having a feature possessed by no other street railway in the world. The road runs from Omaha to Council Bluffs, and is nine miles long, and the cars are of the type known in this country as the "vestibule," built by the Pullman Palace Car Company. In this style of car, with doors at each end, as in the ordinary railroad car, the passage-way formed by the platform of the two cars is housed in with leather, and cloth sides and top, which close and expand like a concertina. In this way the traveller can go from one end of the train to the other, no matter what the weather and the rate of speed, without being in the slightest way exposed or inconvenienced. The application has been very popular on the steam roads, and I have no doubt that it will prove equally so at Omaha, where the severity of the winter is such as to render protection against the elements highly welcome. A yet fuller idea of the magnitude of the enterprise, and the pains bestowed upon it, may be formed from the fact that the road includes a fine bridge, 3,000ft. long, across the Missouri River. If anybody is in doubt as to the prospects of electric railroads, I think I can do no better than refer him to such enterprises as this, which represent the investment of hundreds of thousands of dollars. Another large new Thomson-Houston road is that at Wichita, Kansas, and an even more important undertaking is that at Topeka, in the same State, which will have, when complete, 700 horse-power of generators. The same company has two other new large contracts, those for Cleveland and Louisville, in each of which forty cars will be required. The Sprague Electric Company are also extremely busy on railway work, enlarging old roads and adding new ones to their list. The work at Boston is being pushed forward with all possible speed. A large road has just been started at Akron, Ohio, and another at Lafayette, Indiana; while the operation of the road at St. Joseph, Mo., during the recent tremendously heavy snowstorm, has been most encouraging. In this last case, though the storm practically paralysed all the other means of electrical service, the conductors of the electric railroad stood up bravely, and the cars made their regular trips without delay or stoppage. Every opponent of electric railroads has been saying, with a significant nod, "just wait till winter comes." Well, winter has come, and the roads are doing their work in a much better manner than even their friends anticipated. It really seems wonderful what an electric car can be made to go through when it has a stout motor on it, and the generating capacity of a big station behind it. With regard to the Sprague road at Harrisburg, Pennsylvania, a very flattering report is made by the management. There are now five cars running over five miles of track eighteen hours a day. During the month of September the cost of operating such a service was $1,200; that sum including everything of every nature. The receipts were $3,600, showing a net profit for the month of $2,400, or 30 per cent. per annum on the capital stock. From the Lykens Valley coal mines, where the Schlesinger system has been in operation, another good report comes. One of the motors there a few days ago hauled out 34 loaded cars, representing a total weight of 2,000 mile-tons. The satisfaction given by the plant is shown by the fact that it has been paid for. Altogether, I think it may be said that the outlook for electric railways was never so good, and that great as has been the extension of business during the past year, the growth during 1889 will be infinitely greater.

American electrical manufacturers are gradually becoming accustomed to look upon the West Indies and South America as a good market for their wares. This is particularly the case at the present time with regard to electric lighting, and I am inclined to think that considerable business is being done. One of the largest operations at the present time is that connected with the Island of Cuba, where a franchise has just been granted, by the municipal authorities of Havana, to a company which proposes to light that city, and to do an indoor business as well. The company is supported by American capital and enterprise, and there are good reasons for thinking that the field in Havana will prove a profitable one. But outside of Havana and the other cities, like Santiago-de-Cuba, there is plenty of unworked ground in connection with the various industries, such as the tobacco works, the sugar plantations, and the copper mines. In many parts of the West Indies and Central America there are fine water powers, and as soon as it is ascertained that they are sufficiently stable to be depended upon the year round, there will be a widespread introduction of electric lighting apparatus from this country. In some instances such water power has already been utilised, and the results have been very gratifying.

Speaking of water power reminds me of an enterprise which has just been organised in another part of this hemisphere, that to the north of us. One of the great scenic attractions of the

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fair city of Montreal is the Lachine rapids, and I daresay many of your readers will recall pleasant and exciting hours spent in their neighbourhood. For some time past there has been agitated the question of utilising the water power which is developed on the St. Lawrence in connection with these rapids, but so far nothing has been done. It is now reported from Montreal, however, that a syndicate has purchased the Ile au Heron, and will use the water power there developed for electric lighting in the city. It is asserted that 250,000 horse-power will be available. The building of the dam, bridges, &c., will begin at once, and the cost of the work is placed at about £100,000. It is said that English, as well as Canadian and American capital, is interested. The local Edison Electric Light Company is understood to have quite an active part in the matter. It will be very interesting to watch the execution of this work, not simply for its own sake, but for the bearing it may have on other plans in Canada of an even more extensive character, such as utilising part of Niagara, for example.

It has been quite a popular practice to use the electric light in connection with festivals and sports at night time, and some of our largest areas in the country devoted to athletics, &c., are well supplied with arc lights. An amusing incident which occurred in this city during the past week shows, however, that where football kicking is included in the programme it is well not to have any arc lights in the way. One of the competitors succeeded in putting the ball plump up against one of the lights, shattering it completely, and he followed up this performance by smashing another light, though not so badly. This may be a good way of showing the accuracy of a man's kicking, and perhaps the idea may be utilised in obtaining an exact record of the height of the kick, but it is certainly very hard on the lamps. A big arc light is such an attractive thing that one cannot greatly wonder at its being made a mark of, and it is even asserted that the pernicious activity of our street boys does much to promote the prosperity of the glass factories. Electric lighting is not the only industry of the kind that thus suffers. Out West, as you have probably heard before, it is a constant amusement with the cowboys to use the glass insulators along the telegraph lines as targets, matching each other on the result, so that they often break themselves, the record, the insulator, and the circuit all at once.

CORRESPONDENCE.

SIR WILLIAM THOMSON'S SIMPLE HYPOTHESIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a Paper read before the British Association, at Bath, Sir W. Thomson proposed the following equations for a field of incomplete circuits:—

$$u=\frac{1}{\kappa}\left\{\nabla^{-2}\frac{du}{dt}-\frac{d\psi}{dx}\right\};\quad v=\frac{1}{\kappa}\left\{\nabla^{-2}\frac{dv}{dt}-\frac{d\psi}{dy}\right\};$$

$$w=\frac{1}{\kappa}\left\{\nabla^{-2}\frac{dw}{dt}-\frac{d\psi}{dz}\right\};$$

$$V^2\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}\right)=\frac{d}{dt}(\nabla^2\psi),$$

where $\frac{1}{4\pi\kappa}$ is the conductivity, V is the number of electrostatic units in the electro-magnetic unit of electric quantity, and the remaining symbols have their ordinary meaning.

These equations give, κ being constant—

$$\frac{\kappa}{V^2}\frac{d}{dt}(\nabla^2\psi)=\frac{1}{V^2}\cdot\frac{d\psi}{dt^2}-\nabla^2\psi$$

$$\nabla^2\psi+\frac{\kappa}{V^2}\cdot\frac{d}{dt}(\nabla^2\psi)=\frac{1}{V^2}\cdot\frac{d^2\psi}{dt}$$

$$\kappa\nabla^2 u=\frac{du}{dt}-\frac{1}{4\pi}\cdot\frac{d}{dx}\nabla^2\psi.$$

Maxwell's equations give—

$$\nabla^2\psi+\kappa K\frac{d}{dt}(\nabla^2\psi)=0,$$

$$\kappa\nabla^2 u=\left(1+\kappa K\frac{d}{dt}\right)\left\{\frac{du}{dt}-\frac{1}{4\pi}\frac{d}{dx}\nabla^2\psi\right\}.$$

K is a quantity of the order $\frac{1}{V^2}$, and both K and $\frac{1}{V^2}$ are so small that unless the operator $\frac{d}{dt}$ increases the quantity operated upon in a ratio comparable with the velocity of light, the two sets of equations give results sensibly identical.*

Unless, therefore, we can explore the field with instruments of such delicacy as to detect the existence of electromagnetic actions, oscillating with a rapidity comparable with that of light vibrations, we have no experimental evidence enabling us to form any decision between Sir W. Thomson's and the Maxwellian theory.

Thus, in the field of a leaky condenser, mentioned by Prof. Poynting in *The Electrician* a few weeks back, the absence of any observed magnetic force does not go far to prove Maxwell's view, although its presence would be conclusive against it.

In fact, Sir W. Thomson's field is one in which the currents are, *ex hypothesi*, confined to the conductors, and in those conductors satisfy the equation

$$V^2\left(\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}\right)=\frac{d}{dt}\nabla^2\psi,$$

and, therefore, unless $\frac{1}{V^2}\cdot\frac{d}{dt}$ be finite, *i.e.*, unless the forces in the field be oscillating with the rapidity of light vibrations, u, v, w, sensibly satisfy the equation

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=0.$$

Maxwell's field is one in which the conduction currents satisfy the conditions $\frac{dp}{dx}+\frac{dq}{dy}+\frac{dr}{dz}=\kappa K\frac{d}{dt}\nabla^2\psi$,

i.e., sensibly $\frac{dp}{dx}+\frac{dq}{dy}+\frac{dr}{dz}=0$,

with the above mentioned limitation as to $\frac{d}{dt}$.

And the displacement currents in the conductor and the surrounding dielectric are insensible in comparison with the conduction currents in the conductor being to them in the ratio

$$k K\frac{d}{dt}\cdot \text{P to P}$$

where P is the electromotive force.

The two fields, therefore, are sensibly the same, and the theories merely differ in the fact that one, rightly or wrongly, leads to a magnetic theory of light and the other does not.—

Yours, &c.,

H. W. WATSON.

Berkswell Rectory, Coventry, November 26, 1888.

THE ELECTRO-MAGNETIC EFFECTS OF A MOVING CHARGE.—II.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: All disturbances being propagated through the dielectric ether at the speed of light, when, therefore, a charge is in motion through the medium, the discussion of the effects produced naturally involves the consideration of three cases, those in which the speed u of the charge is less than, or equal to, or greater than v, that of light.

In a previous letter under the above heading (*The Electrician*, Nov. 23, 1888, p. 83), I gave the complete and very simple solution of the intermediate case of equality of speeds. A formal demonstration is unnecessary, as the satisfaction of the necessary conditions may be immediately tested.

But I was not then aware that the case $u < v$ admitted of being presented in a nearly equally simple form. That such is the fact is rather surprising, for it is very exceptional to arrive at simple results, and these now in question are sufficiently free from complexity to take a place in text-books of electricity.

Let the axis of z be the line of motion of the charge q at speed u. Everything is symmetrical with respect to this axis. The

* If κ be so large that $\frac{\kappa}{V^2}$ in the Thomson field, or κK in the Maxwell field, be of sensible magnitude, then u in the former and p in the latter become insensible.

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lines of electric force are radial out from the charge. Those of magnetic force are circles about the axis. The two forces are perpendicular. Having thus settled the directions, it only remains to specify their intensities at any point P distant r from the charge, the line r making an angle θ with the axis. Let E be the intensity of the electric and H of the magnetic force. Then, if c is the permittivity and μ the inductivity, such that $\mu c v^2 = 1$, we have

$$(u<v)\begin{cases} cE = \dfrac{q}{r^2}\dfrac{1-\frac{u^2}{v^2}}{\left(1-\frac{u^2}{v^2}\sin^2\theta\right)^{\frac{3}{2}}} \quad \ldots \quad (A) \\ H = cEu\sin\theta \quad \ldots \quad (B) \end{cases}$$

That (A), (B) represent the complete solution may be proved by subjecting them to the proper tests. Premising that the whole system is in steady motion at speed u, we have to satisfy the two fundamental laws of electromagnetism :—

(1.) (Faraday's law.) The electromotive force of the field in any circuit equals the rate of decrease of the induction through the circuit (or the magnetic current $\times -4\pi$).

(2.) (Maxwell's law.) The magnetomotive force of the field in any circuit equals the electric current $\times 4\pi$ through the circuit.

Besides these, there is continuity of the displacement to be attended to. Thus :—

(3.) (Maxwell.) The displacement outward through any surface equals the enclosed charge.

Since (A) and (B) satisfy these tests, they are correct. And since no unrealities are involved, there is no room for misinterpretation.

When u/v is very small, we have approximately

$$cE = \frac{q}{r^2}, \qquad H = \frac{qu}{r^2}\sin\theta,$$

representing J. J. Thomson's solution—that is, the lines of displacement radiate uniformly from the charge, and the magnetic force is that of the corresponding displacement currents together with the moving charge regarded as a current element of moment qu. Instantaneous action through the medium is involved—that is, to make the solution quite correct.

That the lines of electric force should remain straight as the speed of the charge is increased is itself a rather remarkable result. Examining (A) we see that the effect of increasing u is to concentrate the displacement about the equatorial plane $\theta = \frac{1}{2}\pi$. Self-induction does it. In the limit, when $u = v$, the numerator vanishes, making $E = 0$, $H = 0$ everywhere except at the plane mentioned, where, by reason of the denominator becoming infinitely small in comparison with the numerator, the displacement is all concentrated in a sheet, and with it the induction, forming a plane electromagnetic wave, as described (and realised) in my previous letter.

If we terminate the field described in (A) and (B) on a spherical surface of radius a, instead of continuing it up to the charge q at the origin, we have the case of a perfectly conducting sphere of radius a possessing a total charge q, moving steadily at speed u through the dielectric ether. As the speed is increased to v, the charge all accumulates at the equator of the sphere.

But after that? This brings us to the third case of $u > v$, and here I have so far failed to find any solution which will satisfy all the necessary conditions without unreality. The description at the close of my previous letter must therefore be received as a suggestion at present unconfirmed. I hope to consider the matter in a future communication.—Yours, &c.

OLIVER HEAVISIDE.

P.S.—In a recent number Mr. W. P. Granville raised the question of action through a medium being only action at a short distance instead of a long one, and asked for instruction. His inquiry has elicited no response. This is not, however, because there is nothing to be said about it. The matter did not escape the notice of the "anti-distance-action sage." My own opinion is that the question involved is, if not metaphysical, dangerously near to being so; consequently, whole books might be devoted to it. At present, however, I think it is more useful to try to find out what happens, and to construct a medium to make it happen; after that, perhaps the matter referred to may be more advantageously discussed. The well of truth is bottomless.

ELMORE'S ELECTRO-BURNISHING PROCESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read in *The Electrician* of November 16 a very interesting article on the electrical properties of copper wire made by Elmore's electro-burnishing process, but I regret that there was no mention of how the conductivity was determined. There are two ways, giving results quite different, as M. Mialaret (ingénieur des poudres et salpètres) indicated in a communication to the Société Internationale des Electriciens last year. In the first, the conductivities of two wires of the same length and section are compared; in the other, the conductivities of two wires of the same length and weight are compared. The first method is the more rational, and always gives a higher conductivity than the second. Thus, I read in an article of M. Hospitalier, in *l'Electricien* of July 16, 1887 :—

High Conductivity Wire from Bogny (Ardennes).

	No. 1.	No. 2.	No. 3.
Density	8·897	9·32	9·6
Conductivity, equal volume	102·4	106·7	110·8
Conductivity, equal weight	101·7	101·2	101·6

It is therefore of the greatest importance to mention if the conductivity has been taken for equal volume or for equal weight. You would oblige me very much by indicating this as regards Elmore's copper.

To obviate this confusion it would be better to indicate the specific resistance or the specific conductivity in microhms-centimètres or in mho per centimètres.—Yours, &c.,

GASTON ROUX.

Préparateur de M. Hospitalier à l'Ecole de Physique et de Chimie Industrielles, 51, Rue de Dunkerque, Paris.

CABLE-TESTING—COPPER AND DIELECTRIC RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent "Megohm," I wish first to thank him for his doubtless well-meant intentions in pointing out the error existing in my figures, as published, for the relative effects of pressure and temperature on gutta-percha at 2,000 and 3,000 fathoms depths. It would naturally, I imagine, be apparent that this was only a "slip," as I had already referred to the fact (attained from Sir William Siemens' experiments) that the resistance was increased at a rate directly proportional to the amount of pressure exerted. I did not observe the error (as I ought to have done) until reading over my remarks in your issue of November 16th. It does not, however, alter the general inference that the greater the depth the larger is the share which pressure takes in proportion to that taken by low temperature in increasing the resistance on submergence, though it materially defers the depth at which the pressure has an equal effect on the resistance of gutta-percha with that of the bottom temperature. My example was, however, only intended to give an illustration of the comparative effects of pressure and temperature at various depths. Had it been intended for anything more I should not have spoken of it as the effect produced on gutta-percha *generally*, but, rather, on a particular gum of the same. In referring to the matter further I should have required to state the manner in which the different gums of gutta-percha are affected by the temperature at any depth. For instance, the resistance of some gutta-percha gums (just supposing that they also, at some different degree of age, had a resistance of 600 megohms at 75°F.) would be increased from 600 megohms at 75°F. to 11,641 megohms at 36°F., instead of to 6,737 megohms, as in the case given; whilst that of other qualities would become only 3,373 megohms by the same decrease of temperature.

As regards the other points brought up in your correspondent's letter, I still fancy that 102·38 per cent. is, at the present time, "quite an ordinary conductivity for copper intended for telegraphic purposes;" neither do I think it "will come somewhat

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as a surprise to those engaged in the testing or manufacture of cables," as suggested by your correspondent.

In stating that "the correct coefficient for variation of resistance by temperature is frequently somewhat higher than that given for Dr. Matthiessen's standard, I referred to each particular coil, and not, as your correspondent appears to suppose, to any entire length of cable, in which he rightly points out "an average conductivity of 98 or 99 per cent. is generally considered an excellent result;" 96 per cent. is usually about the conductivity stipulated for in specifications for each "hank" of copper wire composing a submarine cable. I did not wish to be understood that the *average* conductivity was as high as 102·38 per cent., but that inasmuch as such conductivities above 100 per cent. occur frequently amongst the "hanks" of wire, the correct coefficient for temperature would be frequently above that given for Matthiessen's standard pure copper, and on a complete cable the average conductivity is, therefore, often as high, or possibly even slightly above, that of Matthiessen's standard; therefore, it is not unlikely that the absolutely correct temperature coefficient of the conductor would be often as high as (or sometimes even higher than) that for the standard copper. As long ago as in 1883 Mr. Willoughby Smith, in his Presidential Address to the Society of Telegraph-Engineers, gave results of experiments on the conductivity of various samples of copper wire, in which some showed themselves to have a higher conductivity than Matthiessen's standard. Commenting on the same, Mr. Smith said, "These results confirm what I have already mentioned, that some commercial copper has a higher specific conductivity than the long recognised standard for pure copper." If conductivities of 101·4 per cent. were attained in 1883 (instead of 50 per cent. in 1858), it is only natural that such conductivities as 102·4 per cent. should not be uncommon nowadays. In point of fact, if your correspondent tested the copper wire of a certain French firm, he would not, I fancy, find any samples with a conductivity below 101 per cent.

Previous to your correspondent's remarks, I was not aware that a doubt existed as to the desirability of a fresh copper standard being before long adopted.

Your correspondent implies that I suggested that the temperature coefficient for the resistance of the copper conductor should be *determined* by observing its resistance at various temperatures, as denoted by variations in the resistance of the gutta-percha dielectric of any cable. It certainly was not my intention to suggest any such notion.

What I wanted to point out was, that when an opportunity presents itself of observing the resistance of the gutta-percha dielectric as well as of the copper conductor at wide ranges of temperature of known degrees, it was useful to do so, as in the case when a cable is taken out from England in the winter at an atmospheric temperature of, say, 35°F., and passes through the tropics in a water (tank) temperature of 85°F., and then afterwards, in going south, experiences a temperature of, say, 32°F., and then again an equatorial temperature of 80 to 90°F. In the first place, the opportunity is one which it is well to take advantage of (from a scientific interest point of view, at any rate,) in order to observe the rate at which the resistance of gutta-percha answers to a change of temperature of known degree as compared with that of copper. Where a cable is coiled in the tanks aboard ship the temperature of the water may be noted, and after a change in the temperature of this water it is useful to note how soon the copper picks up that temperature (as regards its electrical resistance), and how soon the gutta-percha does so. It might in some ways naturally be supposed that, the copper conductor being enveloped inside the gutta-percha insulator, the gutta-percha would, especially in the case of a laid cable, the soonest adapt itself to any alteration in the prevailing temperature. This does not, however, appear to be the case; in fact, the gutta-percha, as a rule, lags uniformly behind the copper in this respect by about 48 hours. That is to say, in the case of a fall of temperature of 30°F. the gutta-percha of a core would not give its true resistance exactly corresponding to this decrease of temperature till about 48 hours after the copper has done so. This is, very probably, owing to the fact that in the case of gutta-percha the effect of a change of temperature is (by increasing or decreasing its density) that of gradually driving out or absorbing moisture, and thus gradually increasing or decreasing its electrical resistance, whereas in that of a metal it is merely that of altering its degree of homogeneousness. Moreover, on a long outward voyage, passing through a large variation of temperature, by noting the insulation resistance at each of these temperatures as they respectively recur at various stages of the voyage, the variation of resistance due to age can be approximately determined, and the altered degree of variation of resistance due to each variation from the standard temperature (owing to the alteration in specific resistance by age) can be determined for the cable when about to be laid. In this way useful curves may be drawn up showing the variations of resistance by age, and that by temperature of different gums of gutta-percha; and others showing the respective variations by temperature of the said gums at various periods since manufacture of the core.

Inasmuch as gutta-percha takes so much longer to answer to a change of temperature (or become "temporised," as I have heard a jointer express it) than copper does, it might in some cases (as in that of a cable just laid in very cold water) be inaccurate in reducing the observed dielectric resistance to that at 75°F. to correct the resistance by the temperature calculated from the conductor resistance, owing to the fact that the gutta-percha may not have yet adapted itself (as regards its resistance) to such a low temperature as the copper has. Under these circumstances it is sometimes a little useful (even in practice) to calculate the temperature of the dielectric from its resistance, as an additional check on that attained for it by the resistance of the conductor, and, at intervals, by the thermometer. This only is what I wished to imply in my previous remarks on the subject. In this case the effect of the pressure on the resistance of the gutta-percha at that depth would, of course, however, require to be included in the calculation. Your correspondent appears to have unwittingly misunderstood me in this matter, or else he has a partiality for the practise of setting up a figure in order to knock it down again by a process of fertile imagination indulged in, as a rule, only by writers of fiction.—Yours, &c.,

November 28th. CHARLES BRIGHT.

[The above letter arrived too late for last week's issue.—ED. *E.*]

"THE CONDUCTION OF ALLOYS AND SOLID SULPHIDES."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of November 16th contained an abstract of a Paper on the "Conduction of Alloys and Solid Sulphides," by Dr. Gladstone and myself. In one respect the abstract is misleading, as it suggests that one of our experiments leads to conclusions opposed to those of Prof. Roberts-Austen.

Our method was to pass a current through a fused alloy in a U-shaped tube, and to see if the ratio of the resistances of its arms altered when a current passed through. The method evidently assumes that there would be a change of resistance if the current caused a change of composition.

To test this assumption in some degree, we slightly changed the composition of one arm by adding a small percentage of lead, and found a very appreciable change in the resistance ratio. But this change was due to the added lead, and was a justification, so far as it went, of our assumption. Your abstract misleads by suggesting that it was a proof of electrolytic conduction.—Yours, &c., W. HIBBERT.

4, Albert-terrace, Notting Hill-gate, W., Dec. 5, 1888.

THE STANDARD CONDUCTIVITY OF COPPER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Exchange Telegraph Company is to be congratulated on having been able to obtain such high conducting copper for its lines so long ago as fifteen years. Great care must evidently have been taken in its manufacture, or else it was a piece of singular good fortune.

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It is a matter for regret that this high standard has not been maintained, as at the present time the large cable companies consider 98 or 99 an excellent result.

The four sections of the West African Cable Company's line, laid in 1886, have an average conductivity of 97·84, and the seven sections of the African Direct Company's line, laid in the same year, have an average conductivity of 98·2.

Occasionally now when great care is taken in melting electro-deposited copper, some excellent "wire bars" are turned out, and the average conductivity of 98 to 99 is surpassed; but this (usual) method of manufacture cannot be relied on to produce uniformly good results, a conclusion which is emphasised by the above-quoted cable conductivities.

One great advantage (amongst others) of the new process mentioned by Mr. Lant Carpenter in his Paper is that the copper can be absolutely relied upon to *always* possess the high conductivity quoted by him.—Yours, &c., C. J. S.

December 5, 1888.

THE COUNCIL OF THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The voting papers of the Society of Telegraph-Engineers and Electricians are now in the hands of members, and to telegraph men cannot but afford matter for painful reflection. Here is a society initiated, maintained, and made a success chiefly by telegraph-engineers, and yet things have come to such a pass that neither in the Council itself, nor in the list of members recommended by the Council for election, is there a single representative of purely telegraph work. Among the past presidents alone can any such be found, and these it is out of the power of our Council to supersede. As no new members are being added to the list, the time is not far distant when, if we do not take the matter into serious consideration, telegraphy will be entirely ignored. The very name of the Society is about to undergo "rectification," so as to extinguish the last faint glimmer of what was once a powerful factor in the scientific world.

Ten years ago this Society had on its Council such names as Scudamore, Latimer Clark, Preece, Walker, Webber, Willoughby Smith, Bright, Forde, Varley, Andrews, &c. To-day, except among the shelved presidents, there is not a single name known to telegraphy. One by one they have been weeded out, evidently in pursuance of a fixed policy, until recently the last connecting link between the old Society and the collection of professors now in power was ousted so rudely that he withdrew from the Society altogether; I refer to Mr. W. T. Ansell, whose action in this instance many of his friends deplore. He ought to have stuck to his guns for the sake of the principle involved. The telegraph interest is surely strong enough and important enough to insist upon due representation in its own Society, and we ought not to permit our share in the Society to pass out of our hands, if only for the sake of our inheritance in the Ronalds Library, which was left to the telegraph-engineers. The Society was made by telegraphy, and it is not creditable that in an electrical institution room cannot be found for a branch of the science which has done more to benefit humanity and promote the progress of the world than any other agency in the present century.—Yours, &c., TELEGRAPHY.

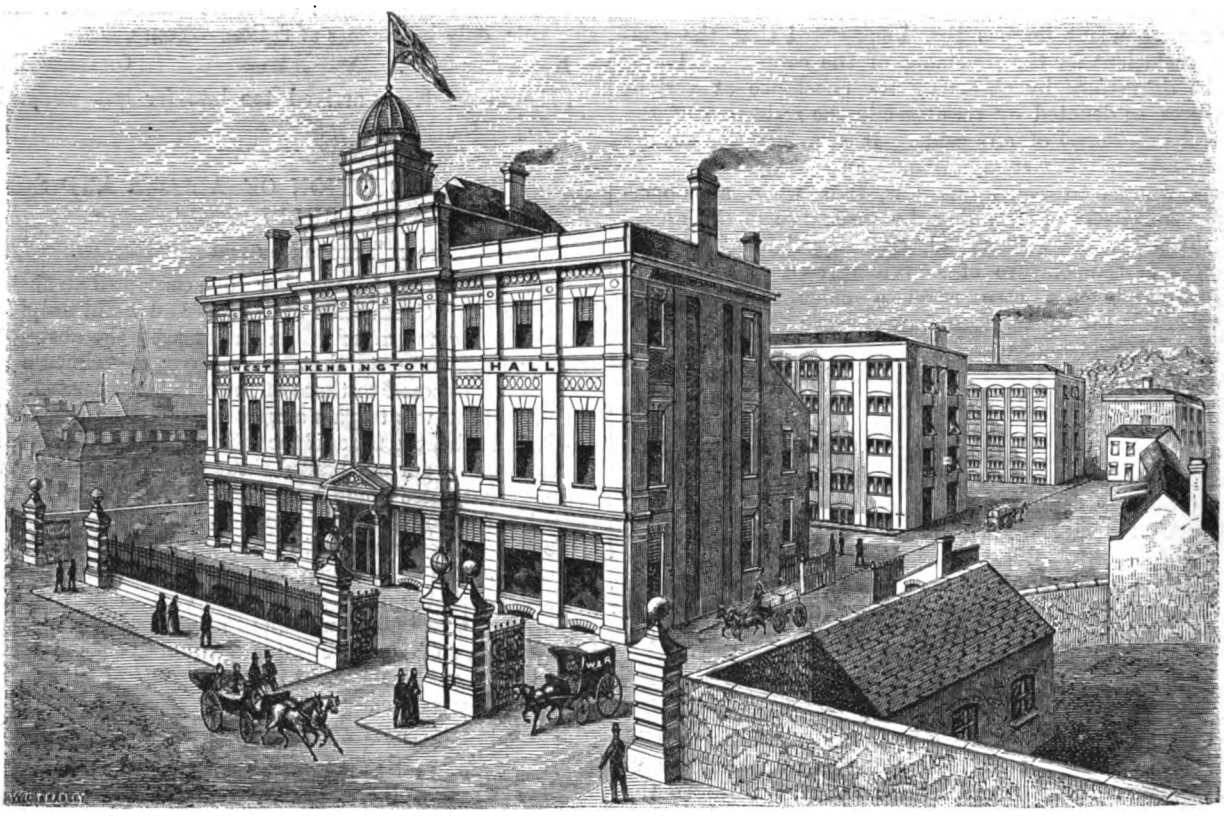
TELEPHONE CALL OFFICES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to my letter of last week, I have now ascertained that the call office at Hall's, in Edinburgh, was opened on the 26th July, 1880. This office was then, and still is, a public one.—Yours, &c., F. FAITHFUL BEGG.

6, Drapers'-gardens, December 4, 1888.

THE WORKS OF THE WOODHOUSE AND RAWSON MANUFACTURING COMPANY AT WEST KENSINGTON.



The above illustration shows a view of the works of the Woodhouse and Rawson Electric Manufacturing Company (Limited). It may be recollected that a few weeks ago (*The Electrician*, August 24, 1888,) we gave a description of the above works. At that time the large block of buildings facing the street was only partially occupied by the company, but we understand that very shortly the whole of the premises—which are at present owned by two of the shareholders—will become the property of the company. We may mention that Messrs. Woodhouse and Rawson have recently received an order for over 100,000 switches; this is probably the largest order for switches ever given out. It is the manufacture of articles on a scale such as this that enables high quality to be supplied at a low price, and we are glad to see such orders, as it affords satisfactory evidence of the progress of electric lighting industry.

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ELECTRIC LIGHTING AND THE KENSINGTON VESTRY.

The Special Committee of the Kensington Vestry upon Electric Lighting at a recent meeting recommended that the Vestry do refer back to the Committee the report of the 13th November, with a view to its further consideration. Mr. Lindsay had given notice of his intention to move :—

"*That the Committee be instructed to report how far the Vestry can arrange with the various companies applying for Licenses or Provisional Orders for electric lighting in Kensington, so as*—(a) *To prevent any one company having a monopoly of any one district, and so as to prevent more than two companies obtaining power to open any one street;* (b) *To prevent the erection of overhead wires, except as a temporary expedient, with the consent of the Vestry, and to ensure the taking down within three years of any such overhead wires as may be temporarily permitted;* (c) *To prevent any claim arising on the part of any company for damage done to underground wires on the occasions of the roads being repaired, unless such damage be caused wilfully or by unworkmanlike conduct of persons in the employment of the Vestry, also that the Committee be instructed to inform the Vestry, as far as practicable, in relation to any company in favour of which they may recommend that the Vestry should consent to the granting of a License or Provisional Order :*—(a) *What is the paid-up capital of such company subscribed by* bonâ fide *shareholders?* (b) *Where such company has, or proposes, to erect its machinery?* (c) *What amount of electric light has been hitherto supplied, and in what place or places, by any such company?* (d) *Whether any such company itself undertakes the preparing the internal arrangements of premises for the reception of the electric light, or what conditions any such company is accustomed to make in relation to this matter.*"

Mr. LINDSAY reminded the Vestry that on the last occasion the committee brought up a report dividing Kensington into four areas, and giving to four companies a monopoly of those areas. An amendment was carried, going to the root of the matter, that the Vestry objected to any monopoly. There was considerable dismay on the part of the committee when that was carried, and he felt that himself and others were bound to show that the view they took was a practical one. He must admit that the members of the committee had given a vast deal more time and attention to the subject than he had, and were much better versed in details, therefore he only ventured to oppose them on a matter of principle, and he asked the Vestry to assist the committee by stating whether they do or do not agree with the views set out in his notices. Anything the committee would have to consider would apply to Prosional Orders only, as no Licences will be granted this year. He had been informed of two facts which the committee ought to have told the Vestry—one was that the London Electric Lighting Company had offered to supply the whole light for Kensington at wholesale price and allow the Vestry to make a retail profit. There might be very strong arguments against that, but he said the Vestry ought to have been told of it. After that was refused, the directors asked the Vestry to visit their works, in order to see whether or not they were competent to carry out what they proposed, but received a curt reply that they had not time to visit Deptford, though they could go to Eastbourne. It was suggested at the last discussion that those companies only should be allowed to light Kensington which had their stations in the parish, in order to facilitate the purchase of the works at the end of 21 years, and he contended that was a ground the Vestry ought not to adopt. Not only was that contingency very remote, but if anything is absolutely certain, it is that local government will be so perfected as to utterly obliterate local authorities so far as the supply of light is concerned. Moreover, the first Act was passed with that provision for the sale of works in 21 years, and under that it was found impossible to get the necessary capital subscribed; the Legislature, therefore, by a new Act, enlarged the time to 42 years, yet the committee decided to make a condition of that which Parliament said should not be a condition. If companies were willing to give up their rights in 21 years, it led to the inference that they were not financially strong, and wished to obtain a concession which would make them stronger, and the Vestry should be especially careful not to give such companies a monopoly. Another point was that if any company made it a condition that they alone should put up the machinery in houses for the light, it pointed to their desire to make a very large profit out of that alone, and they might probably after that give little consideration to fulfilling their obligations to supply the light. He said emphatically that he had no personal interest in any lighting company, but he did wish to secure for all fair consideration by the Vestry. He denied the right of the Vestry to say that consumers should obtain their light only from this or that company, and they would be travelling out of their province to make any such arrangement. Mr. Lindsay concluded by moving the adoption of the instructions given above.

Mr. TORR supported the motion, and opposed the idea of a monopoly, saying that the only possible condition when it could be endured was when it was in the hands of municipal bodies themselves for their own benefit.

Mr. WILSON said the first steps taken by the committee were to prevent monopoly, and there had been no single point raised in the discussion which had not been fully thrashed out in committee. It was unfortunate, perhaps, that their report had been sent in at so short a notice, for had it been amplified, what they had done would have appeared in a very different light, but from want of that the committee had been harshly judged.

Mr. DUFFIELD supported the action of the committee, and said if the instructions were passed, ratepayers would not have electric light for years.

Mr. SAUNDERS, Mr. BRAYE, and other members having spoken in support of a reference back,

Mr. LINDSAY said if the committee would be good enough to consider his suggestions, he would not move them as instructions; but he asked that they would again receive, and perhaps cross-examine, representatives of the different companies.

The matter was then referred to committee, by consent, for further consideration and report.

COMPANIES' MEETINGS.

The Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on Monday last, under the presidency of Mr. John Marks.

The SECRETARY (Mr. Samuel J. Boyce) having read the notice calling the meeting, and the resolutions proposed to be submitted,

The CHAIRMAN said that part of the business that they were met there to discuss was of a contentious character, if he might be allowed to use the term, and part of it was of a non-contentious nature. With regard to the first resolution—to voluntarily wind up the Company and appoint certain people liquidators—he purposed asking the shareholders to be good enough to divide it into two resolutions, for this reason, that the first part of that resolution he would make a resolution entirely by itself—that was to say, that the Maxim-Weston Company be wound up voluntarily, because it seemed to be pretty unanimously agreed that it was necessary that the Company should be wound up. As a matter of fact it must be wound up, because they could not continue. On that head he did not think there would be any opposition to the suggestion of the Directors. But he could gather that there would be some opposition to the appointment of the liquidators, from a circular that Mr. Hugh Watt had issued, in which that gentleman advocated the appointment of a high-class liquidator. He thought, therefore, that it would conduce to the despatch of their business if they dealt in the first place with what he surmised there would be no opposition to, namely, the resolution to wind up the Company voluntarily, and to take the second part of the resolution dealing with the appointment of the liquidators as a separate one. They would recollect that at the last meeting they held for the confirmation of the reduction of the capital it was arranged that, unless 80,000 of the unissued shares were applied for, the Directors would make no allotment. Those 80,000 shares were not applied for—not many more than one-fourth of that number having been applied for—and therefore they did not and could not, in fact, owing to their engagement to the shareholders, proceed to make any allotment; but they returned to the shareholders the money paid on application. The result of the shareholders not coming forward and taking up the minimum number of 80,000 shares was, that the capital that was necessary for the carrying on of the business had not been provided, and consequently there was no help for it but to wind up voluntarily; therefore, he begged to move formally—

"*That the Maxim-Weston Company be wound up voluntarily.*"

In doing that he left ample opportunity for any gentleman to address the meeting on the subsequent resolution, unless there were any gentlemen prepared to propose a direct negative to the one now proposed.

Sir HENRY HOARE seconded the motion.

A SHAREHOLDER said that the Chairman had referred to a circular sent out by Mr. Hugh Watt, but he (the speaker) had neither seen nor heard anything of the kind.

The CHAIRMAN replied that Mr. Watt had favoured only a few of the shareholders with a copy of the document in question.

Mr. BOWYER, as one of the original shareholders of the Company, said he would like to know whether an explanation could be given of the steps that were to be taken to induce a further inquiry into the conduct of the Member of Parliament who was their Chairman with regard to the disposal of the Company's assets, which had been disposed of in a very mysterious manner. Owing to the meagreness of the reports that had been published, those who had not attended the meetings had not been able to gain any information as to what had been done in the matter. He would like to know whether the accountants who had passed those very extraordinary accounts should not be brought to book for it. There seemed to have been some very strange conspiracy somewhere, and he thought some inquiry ought to be instituted, and fairly and fully reported, so that they might know the exact state of the case.

The CHAIRMAN replied that the subject was at present before a court of law, and he would not feel himself justified in anticipating the action. It had not been lost sight of by the Board, who fully agreed with the shareholders that the whole matter of the accounts should be investigated. Entertaining that opinion, they had commenced an action against Mr. Watt.

The resolution having been put to the meeting in the usual way, was declared carried with one dissentient.

The CHAIRMAN said the next resolution was :—

"*That Mr. John Marks, of 113, Great Russell-street, W.C., Mr. J. M. Klenck, 42, Bishopsgate-street Within, E.C., and Mr. Louis Scaby, of 23, Churchfield-road, Ealing, be and they are hereby appointed liquidators for the purpose of such winding up.*"

Mr. HIRSCH formally moved the resolution, observing that he need make no remarks on the subject. They all knew those gentlemen thoroughly well, and he was sure they would do the very best they could for the interests of the Company. It was a matter of very great importance at this particular stage of their affairs that they should be elected unanimously.

Sir HENRY HOARE remarked that he had not one word to say against the reputation or business qualities of the gentlemen proposed because he did not know them; but he would be extremely glad to be told what the position of the Company was, and what those gentlemen had done for the Company, he not having been able to go to their offices for the last five years. Formerly he had been received by Mr. Watt with the greatest courtesy; but it seemed that that gentleman was not in very good odour with the meeting, and therefore, in common justice to Mr. Watt and to the gentlemen now proposed, he would like to hear briefly what was the

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position of the Company and what were the allegations against Mr. Watt.

The CHAIRMAN, in reply, intimated that when they came to the next resolution he would be glad to supply the necessary information.

Mr. HODGE seconded the motion.

Sir HENRY HOARE said that he was desirous of getting the information before giving his vote in support of the election of the liquidators.

Mr. HIRSCH said that there was an easy answer to the last observation, namely, that if Sir Henry had attended the previous meetings he would have heard all that could be said in connection with the affairs of the Company and against Mr. Watt. The time of the meeting ought not to be taken up by giving such information.

Sir HENRY HOARE replied that he had come to the meeting for that information.

Mr. RAMSDEN agreed with Sir Henry Hoare that the information should be furnished now.

Mr. JOHN NEWTON said that, in answer to the question now put, he would like to ask what had Mr. Watt done for the Company. He had heard Mr. Watt boast of having paid dividends, but he (the speaker) could only say that those dividends misled him into taking shares at 5s. that were not worth 5d. Mr. Watt had had possession of the Company for some years, and when he left it there where no funds in the till and no business of any moment being done. Notwithstanding that Mr. Watt took his £1,200 a year, and in addition a commission on all business introduced by him to the Company. The speaker contended that no Director in the world could take a commission on work introduced by him unless it was under the authority of a special resolution carried by the shareholders. Mr. Newton next proceeded to descant on the personal qualifications for the office of liquidators of the three gentlemen included in the resolution. As a member of the Investigation Committee, he was thoroughly convinced that it was not possible to select a better man than Mr. John Marks, or one who would look after their interest with greater zeal or uprightness—that was his opinion of Mr. Marks; he was satisfied he was a sound and good man of business. As for Mr. Klenck, every one who knew him would agree in the opinion that if there were a keen man of business, that man was Mr. Klenck. With reference to Mr. Swaby, he had witnessed the persistent and plucky way in which he had denounced the balance-sheet and withstood the attacks made on him by Mr. Watt, and they wanted some one imbued with that feeling to look after the interests of shareholders.

A SHAREHOLDER expressed his dissatisfaction with the manner in which the Company's affairs had been managed in the past, and said he saw no reason why the new Board would manage them better than the old one, and therefore he also would like to ask what the new Directors had done for the Company and what they proposed to do.

The CHAIRMAN wished to be informed by the last speaker what the new Directors could do coming into a concern of that kind with a balance of £2. 16s. at their command, and writs of all kinds flying about their heads from creditors of the Company. The best thing that they could do was to go to the bank of the Company and ask for an overdraft of £1.000, but the bank would not give the money on the security of the Company, but on that of the individual Directors. Having got the money on their own security, the Directors found the writs so numerous that they could not pay everybody. They inquired into the justice of the claims, and found that in most cases they were just claims, and they did the best they could to meet them. They appointed a firm of chartered accountants to investigate the accounts. What did the latter find? That the balance-sheet which Mr. Watt issued to the shareholders was absolutely false. Mr. Watt showed a false profit of £1,550, and took 5 per cent. commission on the amount. Not only did he take 5 per cent. commission on that profit, but the actual sales which he had entered in the books as *bonâ fide* sales were found to be bogus sales entailing a serious loss on the Company. That was what Mr. Watt had done for the Company, and it was through his management, or rather mismanagement, that the Company stood now where it did. Mr. Watt had sent out a circular as the holder of 8,000 shares, in which he said he could not permit the Company going to ruin without an effort to prevent it. Mr. Watt really held 7,376 shares; but he had actually sold 6,500 of those shares, and as soon as the transfers came into the office the Directors refused to recognise them. They had a lien on those shares, and they asked for the sum of £4,600, which they alleged that Mr. Watt had abstracted from the Maxim-Weston Company.

The resolution was then put and carried with three dissentients.

The CHAIRMAN then said that in considering this reconstruction scheme they had to consider, in the first place, what had brought them to the unfortunate necessity of winding up the Company and reconstructing it. As he had already shadowed forth, they alleged that it was entirely due to the maladministration of Mr. Hugh Watt during the time that gentleman was Managing Director of the Company. The new Board on taking office found everything in the most disordered condition, with the large balance of £2 odd at the Consolidated Bank, while they were inundated with writs from agents and others who had not been paid their salaries for a considerable time, and who had probably been appointed by Mr. Watt, though in the opinion of the new Directors they were not necessary, and also from creditors for goods supplied, and so on. The Board did the best they could under the circumstances. As he had told the meeting, they borrowed money from the bank on their own personal security, and with that money satisfied the creditors as far as they could. As soon as Mr. Watt found that they could carry on the affairs of the Company without him, he started an action in the Court of Chancery for the compulsory winding up of the Company. They defended that petition, and successfully in this way, that the Court decided that, as there were matters of accounts between the two—that was to say, that as the Company had claims against Mr. Watt and Mr. Watt alleged he had claims against the Company—the petition should be dismissed, the two parties paying into the bank in the joint names of the respective solicitors to the Company and to Mr. Watt the sum of £500, to abide the result of the action that the Company commenced against Mr. Watt and the action that that gentleman brought against the Company. That had been done, the money being lodged in the London Joint Stock Bank. The Directors had to find that amount out of their own pockets, to keep things going until the shareholders should be called together, and to know whether they would take up the unissued shares that the Directors had asked them to take up, but which the shareholders would not take up. Each of the four members of the Board found £125 for the purpose named. The Chairman then proceeded to refer to a circular which he said was issued by Mr. Watt on the 2nd October, insinuating accusations of the gravest character against gentlemen of untainted reputation. He read *seriatim* the various charges made in the circular in question, and said that there was not a word of truth in any of them. Coming to the prospects of the Company, he remarked that, provided the scheme proposed was carried out, the shareholders would provide a capital of £15,600, which would be ample to continue the work of the Company. He regretted to say that only during the last month they had to let contracts slip by that would have brought in a clear net profit of £1,500, which would have been sufficient of itself to pay a dividend of 2½ per cent. If they could have done that in the last month, what might they not expect in the remaining eleven months? The prospects of the electric light were never so promising as at the present time, and he felt every confidence that, if the shareholders would only take up the proposed scheme, they would be able at the end of the year to come before them with a balance-sheet that would show a very fair dividend. He hoped the shareholders would show a united front to the world in passing the resolutions before the meeting. The Directors had endeavoured to make their project fall as lightly as possible on the shareholders by proposing that 3d. per share be paid on application, and 3d. on allotment, and the

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balance, if required, at no earlier date than six months. He then read a letter he had received from a lady shareholder, in which she described the affairs of the Company as having been "infamously muddled." The Chairman said that he quite agreed with the remark, adding, "but not by the present Board." He concluded by moving the remaining resolutions, as follows :—

That the liquidators be and they are hereby authorised to sell and transfer, subject to due provision being made for dissentient shareho'ders (if any), all the letters patent, business, property, machinery, plant, assets and effects of the Company, whatsoever and wheresoever, to a company to be formed with limited liability, under the Companies Acts, 1862 to 1886, with a capital not exceeding £75,000 divided into 500,000 shares of three shillings each, for the purpose, amongst other things, of taking over and working the property of this Company upon the following terms :—(a.) *The new Company shall pay and discharge the debts and liabilities of this Company, and also the expenses of and incident to the winding up of the same, and of the incorporation of the new Company, and of the sale and transfer by the liquidators of the assets and liabilities of the Company to the new Company.* (b.) *The new Company shall allot and issue to the liquidators, or as they shall direct, 312,000 shares in the new Company of three shillings each, upon each of which there shall be credited the sum of two shillings, a proper agreement being filed with the Registrar of Joint Stock Companies before the issue of such shares, so that the same may be liable to the payment of one shilling per share and no more.*

That the liquidators be and they are hereby authorised and directed to procure to be allotted to every member of this Company requiring the same one share in the new Company, with two shillings credited as paid thereon, for and in respect of every share held by him in this Company ; provided always that, to entitle the members of this Company to an allotment of such new shares, application must be made for the same in writing within ten days after the posting of a notice informing him of his right to apply for the same, addressed to his registered address in the books of the Company. If no such application is received by the liquidators within the time limited as aforesaid, the right of such members to receive such proportion of shares shall be abso'utely at an end, and the liquidators, in order that the necessary capital may be promptly raised, and the liquidation closed, shall dispose of any shares refused or not applied for as aforesaid to any person or persons, whether shareholders or not, at such price (if any) and upon such terms as the liquidators may think fit.

That the liquidators be, and they are hereby authorised to continue the business of the Company pending the transfer thereof to the new Company, and to consent to the registration of the new Company by the same or a similar name to that of the Company.

Mr. KLENCK seconded the resolutions, and said that the scheme embraced therein was the only way out of their difficulties, and expressed his confidence in the success of the Company if it was carried out.

Mr. STEND supported the resolutions at considerable length, reviewing the history of the Company.

Sir HENRY HOARE thanked the Chairman for his extremely open, candid, and explicit statement, adding that he thought that the Company under the direction of the present Board would prosper, and that he would be happy to give them all the support he could.

Mr. ABRAHAMS (Solicitor to Mr. Hugh Watt) then addressed the meeting, and put a series of carefully framed questions to the Chairman bearing on the legal aspect of the proposed scheme, and on the *modus operandi* to be pursued. He also entered a mild protest against the Chairman's strictures on Mr. Watt in the absence of that gentleman.

In answer to Mr. SPICER,

The CHAIRMAN said their liabilities were as nearly as possible covered by their book debts, which they considered good debts. He then replied to Mr. Abrahams, remarking that the three Directors of the present would be the Directors of the new Company. It was specially provided in the Joint-Stock Companies Acts that the value of the shares of those who dissented from such a scheme was settled by arbitration. Whatever sum the arbitrators for the Company and the dissentients found to be the value of the shares would be paid to the dissentients. He did not feel alarmed that they would have a large list of dissentients, as Mr. Abrahams did. With regard to the expenses of the liquidation, if they wanted a grant for them the liquidators would come before the shareholders and let them fix the remuneration. With respect to Mr. Abrahams' remark that he (the speaker) was prejudging Mr. Watt while the action already referred to was *sub judice*, and that in the law of England a person was assumed to be innocent until he was found to be guilty, the speaker would remind Mr. Abrahams that the Solicitor-General (Sir Edward Clarke), in the case of Watt *v.* Cameron, said that Mr. Watt was an unblushing liar. Therefore he (the speaker) did not think that he had prejudiced Mr. Watt in any respect. The amount of liabilities ranged from £2,000 to £2,500, and they had book debts to that extent.

In further reply to Mr. JOHN NEWTON,

The CHAIRMAN said that the present Directors had not received a penny in the shape of fees or any other form, but, on the contrary, had found money at 5 per cent. to carry on the Company, whereas, when Mr. Watt managed it, and advanced money, he took 10 per cent. for it.

He then declared the whole of the resolutions to be carried by a three-fourths majority. A vote of thanks to the Chairman and Directors brought the proceedings to a close.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 30th, 1888, amounted to £5,600. The directors declare an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended September 30 last, and payable on the 24th inst. The books of this company will be closed from the 17th to the 22nd inst., both days inclusive.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during November was 4,013, estimated to produce £3,100, against 3,343 messages, producing £2,998 in the corresponding month of last year. The traffic receipts for August, estimated at £2,800, realised £2,860.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1888, amounted to £1,950, against £2,115 in the corresponding period last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1888, amounted to £59,862, against £53,454 in the corresponding period last year.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1888, amounted to £45,234, against £39,000 in the corresponding period last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts for November, 1888, amounted to £24,000, and for the period from 1st January to 30th November, 1888, to £250,200. For the corresponding months of 1886 and 1887 they amounted to £239,000 and £242,880 respectively.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended November 30th, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4,672.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended 30th November, 1888, amounted to £5,975.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended November 30th, 1888, were £2,889, as compared with £2,689 in the corresponding period of 1887. The August receipts, estimated at £5,002, realised £5,149.

APPOINTMENTS.—The Board of the Direct United States Cable Company (Limited) have appointed Mr. Tavenor Finnis to be secretary and accountant, and Mr. P. Oscar L. Moll to be traffic manager of the company.

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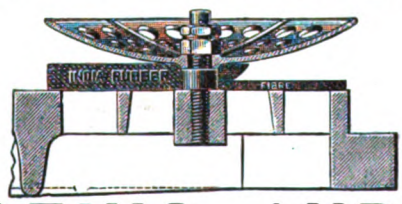

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Dec. 5, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Dec. 5, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	46 47	2 18 6	Jan., Apr., July, Oct.	...	...
2,614,820	Stock	15/0	Do. Preferred	77 78	3 10 6	,, ,,	77⅜	77
2,614,820	Stock	nil.	Do. Deferred	15½ 15⅝	...	February	15⅝	...
130,000	£10	5/0	Brazilian Submarine	13⅛ 13⅜	5 4 8	Mar., June, Oct., Dec.	13⅜	13⅛
16,000	10	9/0	Cuba Submarine	13¾ 14¼	5 19 9	February and August	14⅛	...
6,000	10	10/0	Do. Preference 10%	18 19	5 5 3	,, ,,	18⅝	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4½	3 11 1	March & September	...	...
6,000	5	5/0	Do. Preference 10%	9 10	5 0 0	April and October	...	...
60,710	20	2/0	Direct United States	9⅝ 9⅞	4 1 0	Jan., Apr., July, Oct.	9⅞	...
380,000	10	2/6	Eastern and New xd	12¼ 12⅜	4 16 0	,, ,,	12½	12¼
70,000	10	3/0	Do. 6 per Cent. Preference	14¾ 15¼	3 19 0	,, ,,	15	14⅝
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	109	108½
250,000	10	2/6	Eastern Extension	12⅛ 12⅜	5 2 0	Jan., Apr., July, Oct.	12⅜	12⅛
22,050	10	8/3	German Union Telegraph and Trust	9 9⅛	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅝ 6¾	5 9 1	Jan., Apr., July, Oct.	6 11/16	6 11/16
178,992	10	3/0	Do. 6 per Cent. Preference	14¼ 14⅜	4 2 9	,, ,,	14⅜	14¼
150,000	10	5/0	Great Northern	14⅜ 15	5 0 0	Jan., July, and April	15⅛	14⅜
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
38,348	10	3/0	London Platino Brazilian	7⅛ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7	5 10 6	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	...	...
30,000	10	6/0	West Coast of America	9 9½	5 5 3	January and July	...	...
150,000	100	8%	Do. Debentures 8%	121 125	6 8 0	June and December	12 1/16	...
88,321	10	1% '78	West India and Panama	1⅝ 1⅞	...	...	1⅝	1⅝
34,563	10	12/0*	Do. 1st Preference 6% xd	11⅝ 12	5 0 0	April and October	11⅞	11½
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	12¾ 13¼	5 13 4	March & September	13½	13⅛
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	0 1/16 1 1/16	5 10 0	Yearly	...	...
220,000	£1	2½% '87	Oriental (11s. paid)	3/8 ½	2 14 11	...	...	...
80,000	5	5/0	United xd	13⅜ 14	5 7 2	June and December	13⅝	13⅝
55,000	5	4/6	United River Plate	5⅝ 5⅝	...	January and July	5½	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4 4½	...	...	...	...
23,692	5	nil.	Do. (fully paid)	5 5⅛	...	February & August	5⅛	5 1/16
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅛ 2¾	...	...	2 1/16	2⅛
312,000	¼	5% '86	Maxim-Weston	1/16 3/16	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	40 41	5 17 2	March and July	41	40
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17 17½	5 14 3	February & August	17⅜	17¼

* Account arrears. † No dividend since May, 1880.

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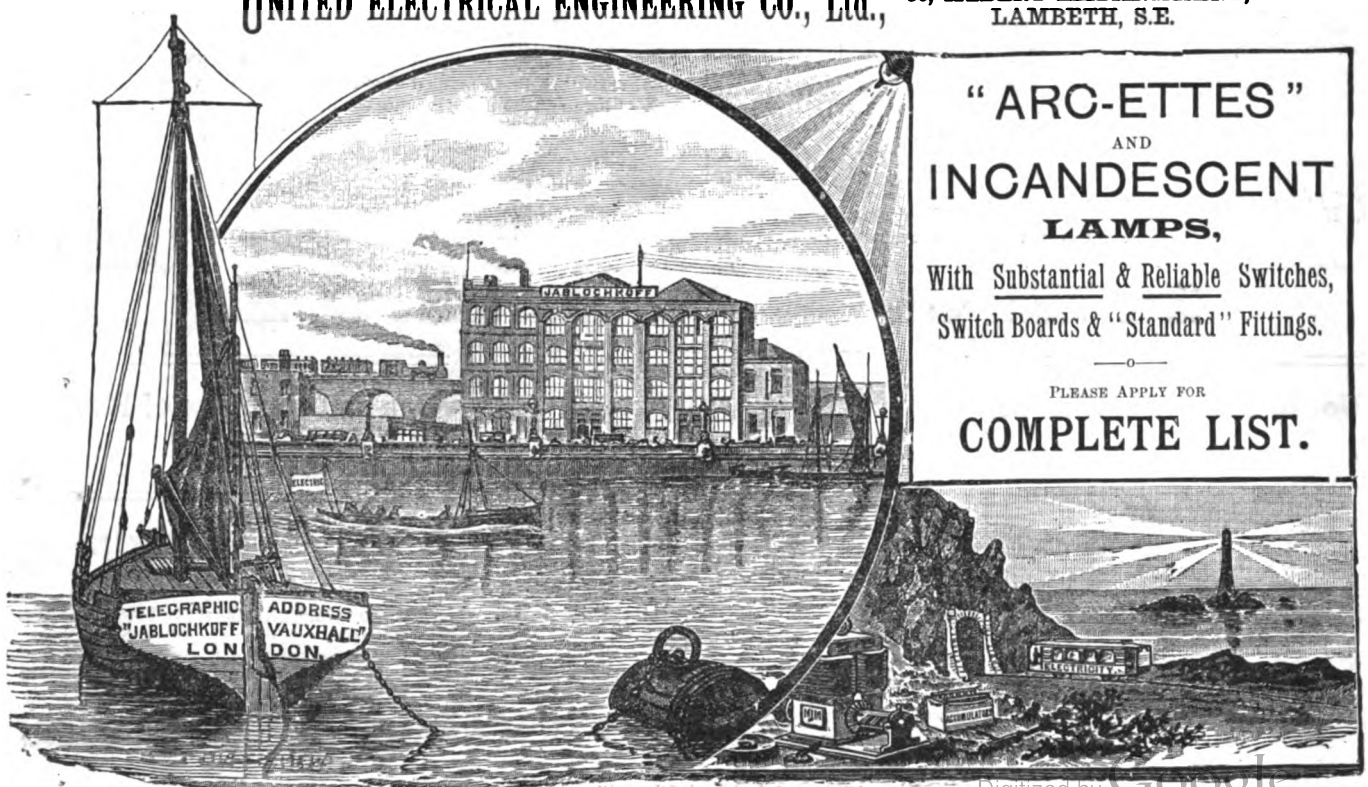

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A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 552.—Vol. XXII. FRIDAY, DECEMBER 14, 1888. Price 4d.

NOTES.

Amongst our correspondence will be found an important letter from the laboratory of Prof. Rowland, from which it will be gathered that preparations are being made for a repetition of the classical experiment on the magnetic effect of convection currents. It will be remembered that Dr. Lecher recently failed in an attempted verification of this experiment, but the actual existence of the effect seems already to have been placed beyond dispute.

We print elsewhere the programme which has been drawn up by the "Preparatory Committee" of the International Congress of Electricians, which is to be held in Paris in connection with the forthcoming Exhibition. The meetings of the Congress will be open to all electricians on the payment of a subscription of 20 francs, and each member will receive a copy of the *Transactions*. The exact date has not yet been settled, but it is understood that it will not be earlier than August 15th. This seems unfortunate, since it will then be inconveniently near, even if it does not clash, with the meeting of the British Association. The Committee is to consist of 100 members, of whom 25 will be French and 75 from other countries. We understand that the invitations will shortly be issued, but the list of names will not appear pending their actual acceptance. We fear that the programme which has been drawn up will not greatly commend itself to the English electricians, but upon that subject we have written at some length in another part of this issue.

Contemporaneously with the alteration of the title of the quondam Society of Telegraph-Engineers and the election of the foremost living Electrician to the Presidential chair, other efforts are to be put forth to raise the general tone of the Institution. This movement, if judiciously directed, must command the sympathy and, indeed, the active co-operation of every electrician who takes a proper pride in his profession. The Institution is undoubtedly fortunate in the possession of a conspicuously successful illustration of what such a society should be in the Institution of Civil Engineers, to whose generous hospitality it is so much indebted. In the dignity and gravity of its proceedings, and in the better organisation of its debates, much benefit would incontestably accrue if the example of the Institute of Civil Engineers were more closely followed. So long, however, as the terms of admission to the membership of these institutions remain on radically different bases, it is manifestly impossible for the younger organisation to emulate the position and status of the elder; but the time has not come as yet for a reconsideration of this fundamental question.

We also understand that, as a step in the direction indicated, and with a view of increasing the importance of the *Journal*, and also as a means of obviating a certain amount of that "playing to the gallery" of which some members are rightly or wrongly accused, a section at least of the Council is in favour of following the practice of the Civil Engineers in the exclusion of reporters from its debates. This is a question upon which much might obviously be said on either side. It might plausibly be argued, for instance, that the presence of reporters has a restraining tendency rather than the reverse. Nor do we feel satisfied that the particular evil complained of exists to so serious an extent as is sometimes alleged. It is not our intention, however, to argue the *pros* and *cons* of the matter, which we shall be content to leave to the united wisdom of the Council. But it is much to be desired that whatever decision may be arrived at will be one that will commend itself to the general body of members, and not merely the result of a bare majority upon the Council itself.

The hearing of the appeal in the case of Ferranti *versus* Gaulard-Gibbs is now fixed for the commencement of Hilary Term, when it will be the first appeal case on the lists.—The arguments in the appeal of Edison-Swan *versus* Holland and others were concluded yesterday (Thursday) evening; judgment being reserved.—The hearing of the evidence in the compound-winding action at the Edinburgh Court of Sessions was concluded on Friday last, but the evidence of Mr. Brush and other American witnesses has still to be taken on commission. Judgment will not, therefore, be delivered until somewhere about the middle of January.

In this action it is part of the defender's case to show that in Varley's specification the words in which the winding and excitation of the field-magnets are described are of an ambiguous character. Of course we do not at present express any opinion whatever upon this point, but it led to a very funny scene in Court. To Professor S. P. Thompson was entrusted the delicate and difficult task of leading the Court to perceive how many separate and distinct inter-

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pretations might be put upon the words "part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets." After the Court had been duly instructed as to the distinction between electric energy and electric current it became necessary to analyse the meaning of the word "divert." This proved a great source of obfuscation, until at length the "principle of bifurcation" was invoked to make all things clear. "Can you suggest," said the cross-examining counsel, "any operation to which the word 'divert' is so appropriate as the operation of bifurcation?" But Prof. S. P. THOMPSON promptly suggested several, so that for the time being things looked just as mixed as ever. A little later on Lord TRAYNER hazarded the surmise that "bifurcation is the production of a current at a certain point." Prof. THOMPSON said "Yes" to this, and then everyone felt better.

IF EDISON held no other claim to immortality—and *some* people believe that he is astonishingly well provided in this respect—he still, we think, deserves all the credit which has ever been awarded him for his invention of the definition-defying term "filament." The highest available forensic, judicial, and scientific skill of this age and country have been brought to bear upon the question, and that not once only but over and over again, and still, as LORD JUSTICE COTTON plaintively remarked this week, we seem to be no nearer knowing what a filament really is. His Lordship inclines to think that it must be something which "is formed before carbonisation;" but this only serves to show how far a reconciliation of legal subtilties and technical obscurities may remove the final issue from the category in which he who runs may read. For if this be indeed the definition of a filament, then our admiration for the inventor of the term will be more than ever profound.

IN connection with the Blackpool Tramway, which, as we recently noted, has now become a most successful commercial concern, our attention has been drawn to the fact that sufficient credit has scarcely been given to the firm of ELWELL-PARKER, to whose co-operation the present success is very largely due. Mr. PARKER's advice and assistance was sought by the directors at a comparatively early stage in the history of the affair, when there were still some serious difficulties to be surmounted. Since this promises to be in some sense an historical undertaking, it is additionally desirable that the credit should be fairly divided, and Mr. HOLROYD-SMITH, we are sure, would be the last person to think otherwise.

WE are very pleased to learn that the tender of Messrs. NICHOLSON AND JENNINGS for the lighting of Cowpen has at length been accepted. The agreement seems to be a fair and honest one on both sides, and it is at least evident that the contractors are not attempting to use this installation merely as a stalking-horse or an advertising boom, as has, unhappily, so often been the case in the history of electric lighting. The terms are 18 arcs for £575 per annum. We look forward to a genuine success at Cowpen, which will do something towards wiping out the disgrace of Barnet.

As to Barnet—what can be said, except that nothing could be more unfortunate for everybody concerned? What makes it all the more annoying is that, in reality, it is such a *very* simple matter to keep a few dozen lamps burning—if only proper engineering skill be exercised in planning and erecting the installation. Of course, if the rumour be true that the mains were cut on Saturday last by some malicious person or persons, this latest incident does not reflect any personal discredit upon the contractor, but it is most devoutly to be hoped in such a case that the miscreants will promptly be brought to justice. The other rumour, to the effect that Mr. JOEL selected Saturday evening as the most appropriate occasion for making some changes in the machinery, may probably be dismissed as hypothetical. But no explanation, however exculpatory, can do away with the mischief created by the fact that, as all the world now knows, the electric light has again signalised its unreliability—at Barnet.

DUBLIN is not only a badly but an expensively-lighted city, and it is natural that strong efforts are being made there to introduce the electric light in the main thoroughfares and principal places of business. The price of gas in the Irish metropolis is abnormally high, and there should be no great difficulty in providing electrical illumination at a charge which would compare favourably with that now levied by the local gas company. Nevertheless, among the members of the Corporation of Dublin, as elsewhere, there are some who take a lively and apparently not altogether unselfish interest in the supremacy of the gas-works. Consequently a good deal of very unseemly wrangling, to say nothing of unparliamentary language, characterised a recent meeting of the Corporation to discuss the question of raising the necessary funds to lay down the plant for electric lighting. In the end the proposition appears to have been defeated for the time being by the casting vote of the chairman. This close voting, coupled with the circumstances referred to above, induce us to think that the subject has not been finally disposed of, and that before another winter the city of Dublin will be permitted to test the merits of the light of which it stands so much in need.

WE understand that the machines at present in use at the Whitehall Central Lighting Station are to be replaced by Siemens dynamos, and the present batteries by Elwell-Parker cells. As this change is not unlikely to lead to legal proceedings, more will doubtless be heard of this anon.

FROM a French source we learn that some of the Roman Catholic citizens of the United States are anxious to avail themselves of the privilege of the confessional by means of the telephone, and that the subject is now occupying the serious attention of the Church. It has already been reported that the United States Courts have allowed an offender to plead guilty by telephone—if we recollect aright he was fined five dollars. But, considering the attitude which the Roman Catholic Church has hitherto studiously observed towards scientific progress, it will be strange indeed if the telephone becomes an adjunct to the confessional—even in the United States.

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UNDER the attractive title of "Electric Lamps from Cabbage Leaves," a provincial journal has been made the victim of one of the most delicious skits which we ever remember to have come across. The article is too long for quotation in this place, but will be found at the end of the "Notes."

Melbourne Exhibition Awards.—We are glad to learn that Messrs. Ransomes, Sims and Jefferies (Limited), of Ipswich, have just been awarded a gold medal for their steam engines at the Melbourne Centennial Exhibition.

The Electric Light on the New Pullman Train to Brighton.—The new "Pullman Vestibule Train" now running between London and Brighton is profusely supplied with the electric light. The dynamo is carried in the brake van, with the 32 E.P.S. accumulators, which are capable of affording a 10 hours' supply. The dynamo is geared on to the axle of the brake van in the well-known manner designed by Messrs. Stroudley and Houghton.

The Ipswich Central Station.—The central station at Ipswich, which has been carried out by Messrs. Lawrence, Paris and Scott, commenced last week to supply current to the offices of the *East Anglian Daily Times*, and as soon as other machines are in place the lighting will be extended to the premises of other private consumers. The engines have been supplied by Messrs. Ransomes, Sims and Jefferies.

St. Pancras Vestry.—At the last meeting of this vestry a notice was read from the Metropolitan Electric Supply Company, notifying their intention to apply for powers to light Hampstead, St. Pancras, and Islington with electricity. A similar notice was received from the London Electric Supply Corporation in reference to lighting with electricity the whole or greater part of the metropolis. A letter was read from the House-to-House Electric Light Company on the same subject with reference to St. Pancras.

"Calvert's Mechanics' Almanack."—The sixteenth number of "Calvert's Mechanics' Almanack" is as replete as ever with tables, formulæ and information of all sorts. We notice a clear and concise summary of the Patent Law Amendment Bill, and amongst other useful items some carefully compiled hydraulic memoranda, a table of the tensile strength of manganese steel bars, and an interesting note upon the action of oils on metal. This little publication ought to prove of great use to all engaged in mechanical and kindred operations.

A Curious Effect of a Lightning Stroke.—A correspondent writes us from Paisley as follows:—A curious effect of a lightning stroke was observed a fortnight ago at some bleach works five miles from this town. A chimney attached to the works was struck by lightning, and about 20ft. of the top destroyed. The lightning conductor was earthed in a pond which supplies the works with water, and after the flash it was noticed that a great many little fish (minnows) floated to the surface dead, evidently having been killed by the discharge.

The Paris Exhibition.—It has been declared by an Order in Council that the conditions of the Patent Act, 1883, under which an application for a patent is not to be invalidated by the exhibition of an invention at an International Exhibition, are to apply to the Paris Universal Exhibition, and also that exhibitors are to be relieved from the conditions of the above Act, under which they were required to give notice to the Comptroller of Patents of their intention to exhibit the article afterwards sought to be patented. The regulations also apply to designs intended to be registered.

The Pall-mall Central Station.—At the last meeting of the St. James's Vestry Mr. Keevil called attention to a huge smoke shaft which is being erected not far from Marlborough House, for the purposes of the Pall-mall Electric Lighting Company. He said that he feared that the vestry did not realise the importance of the proceeding when a majority gave the concession for the erection of a shaft in such a central position. He moved that the whole question be deferred until the new County Council had an opportunity of considering the subject. The motion was lost, and Mr. Keevil then said that he would convene a meeting of the ratepayers for the purpose of calling attention to the matter.

American Storage Batteries.—We learn that the Woodward Electrical Company, of Detroit, have arranged to supply the Detroit battery to the English market. Messrs. Shippey Brothers (Limited) have been appointed sole agents for the United Kingdom, pending the establishment of works in England, to manufacture the Woodward plate for the European markets. We understand that the patents of the Woodward battery are held by a very powerful group of American capitalists, who have recently extended the works, in order to turn out 500 cells per day. Messrs. Shippey Brothers will shortly have on view a complete range of batteries, in all sizes, for lighting, traction, and medical purposes.

Reckenzaun's Tramcars in the United States.—In our "American Notes" of November 9th it was stated that Mr. Barr, the president of the Lombard and South-streets lines in Philadelphia, expressed his entire satisfaction with the performance of Reckenzaun's car, which had then been running for many months in ordinary daily service. Advices have now been received of the successful introduction of the same system in the City of Sacramento, California. The inauguration took place on the 20th ult., on the lines of the Central-street Railway, four miles long, which has been especially built for electric traction, with accumulators. These cars are similar in design to the one we describe this week in another column, and which has been made for a tramway in Australia.

Acceptance of a Tender for the Lighting of Cowpen.—On Wednesday, the 5th inst., an informal meeting of a committee composed of all the members of the Cowpen Local Board was held to consider the advisability of lighting the town with electricity. The chairman (Mr. Robinson) said he had called the meeting for the purpose of hearing an explanation from Mr. Nicholson, of Messrs. Jennings and Nicholson, electrical engineers, of London. After the explanation and conference, a memorandum of agreement was drawn up and initialed by the chairman on behalf of the Board, and by Mr. Nicholson on behalf of his firm, for lighting the township by electricity. On Friday, at a special meeting of the Local Board, it was unanimously decided that the tender of Messrs. Jennings and Nicholson, to light Cowpen township with 18 arc lights for £575 per annum, with option to purchase the plant during the five years' term, be accepted. The township has been in darkness since August, so that considerable satisfaction is expressed with the decision of the Board.

The Smithfield Show.—Messrs. Robey and Co. are exhibiting several of their well-known engines at the Smithfield Show. Amongst others a ten horse-power (nominal) horizontal steam engine fitted with their trip-expansion gear and their electric regulators, by means of which the engine adapts its speed to the number of lamps burning, and can also adapt itself to the work of charging accumulators. Messrs. Robey and Co. also show a six horse-power vertical engine, an eight horse-power portable engine, and an eight horse-power horizontal engine. Amongst several exhibits of interest to agriculturists, Messrs. John Fowler and Co., of Leeds, show a useful-looking compound semi-portable engine, intended for electric lighting work, in which special attention has been paid to the maintenance of a constant speed under wide variations of load. Samples of Tatham's lead-covered cables and wires are also shown by this firm. Great care has been taken to secure high insulation for the electric light leads, low capacity for the telegraph wires, and a minimum of induction in the case of the telephone cables.

Telegraphy to the Continent.—On Monday last, in answer to Sir G. Campbell, Mr. Raikes stated that when the Post Office undertakes the working of the cables to the Continent the charge per word to Belgium will not at first be altered, but the charge to France, which is now 2½d., will be reduced to 2d. No particular proportion of the charge has been assigned to the cable transit. He was not in a position to give any information

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as to the acquisition of the plant of the Submarine Telegraph Company, as no agreement on the subject had been arrived at. No pains will be spared by the department to ascertain the necessary cost of services such as this. Notice has since been given of several questions indicative of apprehension that the acquisition of the Submarine Telegraph Company's cables will be made at a price that will render necessary excessive rates for messages when the cable comes under the charge of the Post Office. It will be remembered that the terms of the company's charter, now about to lapse, do not include any provision for compensation. The cable and working plant will be taken over at a valuation.

Exports of Telegraph Wire, &c.—Our exports of telegraphic materials are generally small in November. The value of last month's exports, though larger than in the corresponding months of the two previous years, have virtually done nothing to redeem the unsatisfactory aggregate of this year's shipments, compared with previous years. The trade returns issued a few days ago enable us to give the shipments for the month, and the aggregate to November 30th, of telegraphic wires and apparatus connected therewith :—

	1886.	1887.	1888.
First quarter	£124,074	... £131,879	... £88,077
Second „	354,331	... 56,933	... 156,136
Third „	412,216	... 468,252	... 152,926
Nine months.....	£890,621	... £657,064	... £397,139
October	60,467	... 31,475	... 17,038
November	14,093	... 14,089	... 18,566
Eleven months ...	£965,181	... £702,628	... £432,743

The Proposed Pacific Cable.—We take the following editorial from the *Daily News* of December 11th :—"At the Congress of representatives of the Australian Chambers of Commerce, held on November 1, 1888, in Melbourne, a Paper upon the proposed new Pacific cable *viâ* British North America was read by Captain F. C. Rowan, who thought a second cable was necessary for mechanical, commercial, and political reasons. In such an ocean as the Pacific there is great danger of a single cable being broken or destroyed, which renders a duplicate cable almost imperatively necessary. Secondly, the saving to England and the Colonies by a consequent reduction of the tariff would be in the course of ten years over five million pounds; and, thirdly, it would more firmly unite the whole of Australasia with the Mother Country." Such are the chief points of Captain Rowan's address; but in speaking as if the cable were already laid, he does not appear to make much of the extreme difficulties of the enterprise —difficulties that are at once apparent when the immense depth of the Pacific Ocean and the liability to breakage on the coral reefs are taken into consideration.

The Counter-E.M.F. of the Arc.—The *Centralblatt für Electrotechnik*, No. 28, has a paper by Herr Hans Dubs, on a simple experiment relating to the above. Realising that in the arc itself there are so many other complicated phenomena present that renders the results obtained uncertain, he took a more simple case. Two pieces of carbon (both broken off the same plate) were placed with their edges rather less than a millimeter apart, and a benzine blowpipe jet turned on blowing from one to the other across the opening. On joining the two plates through a galvanoscope a deflection was obtained, the current always flowing the reverse way to the jet, *i.e.*, if the jet blew from plate *a* to plate *b*, the current was from *b* to *a* and *vice versâ*. A stronger current was obtained by heating a part of one carbon in a hydrogen blowpipe and bringing it in contact with the other, the current flowing from the cold to the hot. The same experiment with copper gave a less effect, and with iron hardly any. He mentions that the electric furnace at the Neuhausen Works, which takes a current of some 12,000 amperes, gives a considerable return current for some time after the main current has been cut off. Herr Dubs hopes shortly to repeat his experiments with a more powerful blast and to make some electrometer measurements.

The Society of Telegraph-Engineers and Electricians.—A special general meeting of members of the Society of Telegraph-Engineers and Electricians will be held at the offices of the Society, No. 4, The Sanctuary, in the City of Westminster, on Thursday, the 20th day of December instant, at 5 o'clock p.m., when the resolutions respecting the change in the title which were passed at the special general meeting of members on the 22nd November, 1881, will be submitted for confirmation as special resolutions pursuant to Section 51 of the Companies Act of 1862. This meeting is rendered necessary owing to the discovery that the previous meeting was informal, a period of fourteen clear days from the passing of the resolutions as required by the Act not having transpired. At the same meeting the following further resolution will be proposed, and if passed by the required majority, it will be submitted for confirmation as a special resolution to a further special general meeting of members, which will be held at the Institution of Civil Engineers on Thursday, the 10th day of January, 1889, at a quarter before eight o'clock in the evening :—Resolution : "That the Regulations of the Society of Telegraph-Engineers and Electricians, as contained in their Memorandum and Articles of Association, be altered by substituting the name 'The Institution of Electrical Engineers' for 'The Society of Telegraph-Engineers and Electricians,' and also by substituting the word "Institution" for the word 'Society' wherever the same respectively occurs in the regulations."

Barnet in Darkness.—We take the following from the *Daily Chronicle* of December 10th :—"Saturday night was the third occasion, since the adoption of the electric light, on which the town of Barnet has been plunged into darkness by reason of some mishap or defect in the arrangements for public lighting. On this occasion the electric light was brilliant from dusk to about half-past seven, when it suddenly went out. The occurrence was particularly unfortunate as the streets were very busy at the time, and numbers of persons resident in the town and in the surrounding villages were engaged in shopping. A thick fog prevailed, and for some time pedestrians were literally groping their way. The police were on the alert, but some few tradesmen complain of the loss of certain of the wares which were exposed for sale outside their shops. It was alleged that a wire had been maliciously cut, and the circuit so broken, and further that a workman recently discharged by the contractor was suspected of the outrage. A more probable explanation, however, is to be found in a letter which the contractor recently addressed to the local board, informing them that he was about to make a change from temporary to permanent engines and plant, and asking to be excused if, in the transition state, any hitch should occur. Whatever the cause may have been, the light was not again available for nearly two hours. At a previous meeting of the Barnet Local Board Mr. Yolland attended, and complained that for three nights one of the lights in Park-road had not been alight. The Chairman (Mr. C. Stevens) stated that the Board "are spending a great deal of time on the subject of the lighting of the town." This, however, did not satisfy the complainant; and he asked that an oil light should be placed in the gas lamp, to which the Chairman replied : "We must not do that; but we are seriously considering the matter." A letter was then read from the Board of Trade informing the Board that it would be necessary for Mr. Joel to acquire statutory powers for lighting the district of the Board with electricity; and the Clerk was instructed to inform the Board of Trade that, under his contract with the Board, Mr. Joel had to do so at his own expense if it was required. The Board subsequently went into committee for the consideration of the subject of electric lighting, and, after lengthened discussion *in camera*, instructed the Clerk to give notice to Mr. Joel to remedy the defects in the lighting within fourteen days.

Leamington.—At the recent monthly meeting of the Leamington Corporation, a discussion took place respecting the lighting of the Parade with electricity, by the Midland Electric Light and Power Company. Some time ago the company erected four arc lamps outside the town hall and several "sunbeams" in other parts of the town, in order to give the Council an opportunity of saying which system they preferred.

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The question now arose on a report by the Watch Committee, who recommended that a decision should be at once arrived at respecting the three alternative systems, and calling upon the company to state forthwith the cost of supplying each system, as well as all charges for maintenance.—Alderman Wackrill, in moving the adoption of the report, urged that sufficient time had been allowed to enable the Council to form a judgment as to the relative merits of the three systems.—Alderman Gilbert seconded the proposition, and said that the company had been playing with the town.—Mr. Davies repudiated the notion that the Council had unfairly criticised Messrs. Chamberlain and Hookham, or had in any way cast reflections on their ability as electrical engineers. Those gentlemen had promised to give the best possible exhibition of the arc system, but the result had been unvariably unsatisfactory, one arc light being always bad, frequently two were defective, sometimes three, and occasionally the fourth. The "sunbeam" system furnished a beautiful light, but as it involved an outlay of £600 a year its adoption was practically out of the question. The fifty candle-power lamps in Bath-street would entail a still greater permanent charge. On Sunday night anyone who saw in the soiled glass globes on the Parade and the red firefly which they contained would be out of his senses to imagine that such a light would attract people to Leamington. The light would not attract a moth. In his opinion the cost of lighting the Parade efficiently by electricity would be so great that the game would not be worth the candle.—Mr. Fell complained of the dirty condition of the lamps, and said that many of them were only giving six candle-power light instead of sixteen.—Dr. Thursfield called attention to the increased cost of maintenance of the "sunbeam" burner, the life of which was, he said, comparatively short, while the light became dimmer the longer it was burning.—Mr. Barter-White hoped that care would be taken not to exceed the term —which expires on Thursday next—during which the experiments were to be continued without prejudice to the existing contract.—The report of the Watch Committee was unanimously adopted, and it was agreed that a meeting of the General Purposes Committee should be held at an early date for the purpose of discussing the question, after the electric-lighting company shall have submitted the cost of the several systems now before the town.

The Swinburne Incandescent Lamp.—In the *East Anglian Daily Times* of Friday, December 7th, the following letter appeared as an article in the front page, and was evidently inserted in the most perfect good faith :—

"A NEW INDUSTRY AT CHELMSFORD."

"ELECTRIC LAMPS FROM CABBAGE LEAVES."

"Mr. Vandeleur, of Moulsham, writes :—I think your readers may possibly be interested to hear something about the new process for making incandescent or 'glow lamps' for electric lighting, which has been worked out by Messrs. Swinburne, and which, if commercially successful, will be an entirely new industry for Chelmsford. Briefly the process is as follows, certain essential details, however, which the inventors prefer to keep secret for the present, being of course omitted. The essential novelty of the process consists in employing vegetable fibre for the 'filament' or thread. Almost any plant leaf will do, but after experiment it has been found that the leaf of the common cabbage answers the purpose best, as it is tough and fairly homogeneous in structure. Each leaf is first separately examined by polarised light to detect any flaws or holes, the smallest pin-hole rendering the leaf practically useless. It is then soaked in vinegar for twenty-four hours in order to neutralise the alkali in the fibre, and after thorough washing is ready for the next process. It is now laid out flat in a solution of mercury bromide ; a rod of specially-prepared shellac is then taken, and after being raised to a high potential condition by treatment with a silk exciter, it is put into contact with the mercury solution. By this means the leaf is gradually electrolysed, the potassium and sodium in the fibre combining with the mercury to form a coating of amalgam. In this state the leaf is a capital conductor, and the inventors have even succeeded in using it as a substitute for lead in secondary batteries. A heavy current is now passed through it so as to carbonise the vegetable fibre, the current being increased till every trace of amalgam is volatilised. It is then cut into filaments, and each is forced through a draw plate of polished chlorine. As it is not of sufficient "resistance," resort has to be had to a process called "flashing." This consists in passing a mixture of neumonia and hydrogen gases over it while it is heated by the electric current. The scaly brown incrustation of carbon monoxide is reduced by the pluroneumonic acid formed (the exact reaction is not known, but is something of this kind—HN3+OC2+J=JO2+H5). The resistance rapidly rises, and at the proper point the current is automatically cut off by an ingenious switch arrangement. The filament is now bent into horse-shoe form and is ready to seal into the bulb. Perhaps the most important discovery made by Messrs. Swinburne is the enormous increase in light that can be obtained for a given current by employing an atmosphere of slightly compressed oxygen in place of the complete vacuum hitherto customary ; and though by this means the life of the lamp may be slightly shortened, it is not considered important in view of the great gain in light. If this process, beautifully simple as a laboratory experiment, should prove commercially successful, large quantities of picked and selected leaf will be required, and Messrs. Swinburne contemplate inviting tenders from some of the leading growers in the county. The bulk of the plant has been already erected, and Messrs. Crompton and Co., of Chelmsford, who are working overtime, have got the machinery well in hand, and hope to complete delivery by the 24th inst."

The Proposed Electric Lighting of Dublin.—At a special meeting of the City Council of Dublin on last Wednesday week the question of the electric lighting of the city was discussed on the estimate of the Finance and Leases Committee coming up for confirmation.—The High Sheriff (Mr. J. Winstanley), in moving the adoption of the estimate of the Finance and Leases Committee, said that the figures were rather alarming, being £6,795, as against £3,651, an increase of £3,144. The adoption of the electric light would alone cause about £2,300 of this additional expense.—Mr. Shanks pointed out that there was an estimate for £804 to meet expenses in connection with a loan for £6,000 for electric lighting purposes. He was not aware the Council had sanctioned such a loan.—The Town Clerk replied that the Council had authorised the obtaining of a license, and necessary expenses in connection with it.—Mr. Dawson moved a reduction of the amount of the estimate by £1,404, made up as follows :—£804. 15s. expenses in connection with the electric lighting loan ; £500 for maintenance ; and £99 less cost of collection.—Mr. Gill said he believed the corporation were going into a thing which would entail an enormous expense on the community. People might say : "Oh, you are a gas shareholder, and have no right to speak on this matter." Notwithstanding that he was a shareholder in the gas company, he considered himself, as a member of the Council, bound to protest against the enormous expense that was going to be put on the city. The Corporation were rushing into an enterprise the end of which no one saw, and which would saddle the citizens with probably £25,000 of expense. He believed the gas company were also going in for electric lighting ; but they had some reason of their own. It was not for any profit they would make through it, because he believed both the gas company and the Corporation would incur heavy loss. He might point out that in parts of America where electricity was successful, it competed with gas at from 12s. to 15s. per 1,000 cubic feet, instead of 3s.—Mr. Doyle said it struck him as an anomaly that Mr. Gill, who was a large shareholder of the gas company, should oppose this motion, when the gas company themselves were about to apply for a Provisional Order for the purpose of enabling them to furnish electric light. His reason for voting for the experiment was that he thought the monopoly of lighting should not be altogether in the hands of the gas company.—The High Sheriff intimated that he would assent to the reduction of the estimate by £1,400. It would stop the loan for a year. On a division being taken on the amendment the voting was equal.—The chairman, believing that it was the wisest course for the Council not to press for the money, said he would give his casting vote for the amendment.—Mr. Robertson moved a further amendment :—"That the estimate be reduced by £402. 7s. 6d. (instead of £804. 15s.) to meet the expenses of a loan for the expenses of electric lighting."—Alderman Byrne, in seconding the amendment, said the committee could not get the work done for them by a small contractor if the money was not forthcoming for a year. Only a large contractor, who would charge more, could wait out of his money for a year.—After a prolonged discussion a division was taken ; and the numbers being again equal, the chairman gave his casting vote against the amendment ; and Mr. Dawson's amendment, reducing the committee's estimate to £5,200, was adopted

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 101.)

Comparison of Theory and Experiment.—Masson and Breguet carried out a series of experiments on induced currents. The principal part of their apparatus was a commutator keyed on a revolving shaft, which enabled them to separate the direct and inverse-induced currents. Two brass wheels were keyed on one shaft, but insulated from it, and the wheels had depressions cut in their periphery which were filled up with ivory. These wheels could be shifted relatively to each other, and were insulated from each other and from the shaft (*see* Fig. 12). Two springs pressed against the edge of the wheels, and two against the hub of the wheel. The whole arrangement served as a means to break and make one circuit, and at the same time to control a second circuit so that it was broken at the time when the first was made, and made at the time when the first was broken, or *vice versâ*. One of these wheels was inserted in the circuit of a primary coil and battery, and the other in the circuit of a secondary coil and galvanometer. On rotating the wheel at a certain fixed speed the series of "break" and "make" induced currents are separated out; all one set are stopped out and all the other are sent through the galvanometer. In this way it was shown that the quantities of the induced currents were equal, but very different in maximum magnitude, and hence in duration, the break-induced currents being greatly superior in making sparks.

Lenz* wound a spiral of wire on the soft iron armature of a magnet and connected the ends of the wire to a ballistic galvanometer. He detached the armature suddenly, and ob-

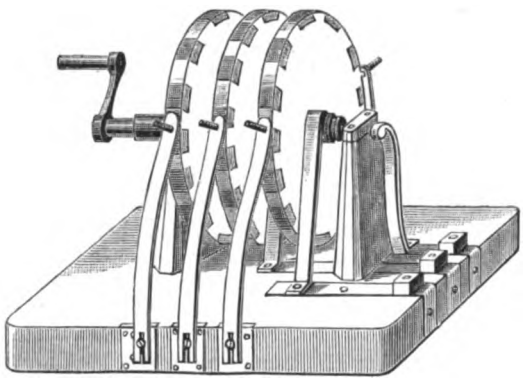

FIG. 12.

served the throw of the galvanometer. If θ denotes the angle of deflection and x the number of windings, he found that the product $\frac{1}{x}\sin\frac{\theta}{2}$ was a constant quantity, which shows that, *ceteris paribus*, the quantity of electricity set in motion was in proportion to the number of lines of induction withdrawn from the circuit. He also established experimentally, in confirmation of Faraday, that the electromotive force of induction was independent of the width, thickness or material of the wire windings,† and by other experimentalists also the fact has been established that the electromotive force is independent of everything except the form of the conductor and the nature of the change it experiences in relation to the magnetic induction through it. Felici‡ carried out an extensive series of experiments on induction, using a form of induction balance.

In this apparatus a secondary circuit, consisting of two coils, is arranged in series with a galvanometer. These coils are so far apart as not to influence one another. In contiguity to each secondary coil is a primary coil, and the primaries are wound in opposite directions. The primaries are in circuit with a battery and a key. The circuits can be so arranged, by adjusting the distances of the coils, that the induction of the primaries on their respective secondaries balance each other, and the galvanometer indicates no current, however strong may be the primary current. If three pairs of coils (*see* Fig. 13) are thus taken and balanced, two and two, so that the induction of A on *a* is equal to that of B on *b* and C on *c*, then, if we connect the primary A in series with B and C in parallel, so that the current divides between them in the ratio of their resistances, and connect the secondaries with a galvanometer, all in series, so that the current in *a* is opposed to that in *b* and in *c*, then no induced current is detected when the battery circuit is made and broken. This proves that the quantity of the induction current is proportional to the strength of the primary current.

If a primary and secondary coil are taken in fixed positions and the "throw" of a galvanometer observed when a definite

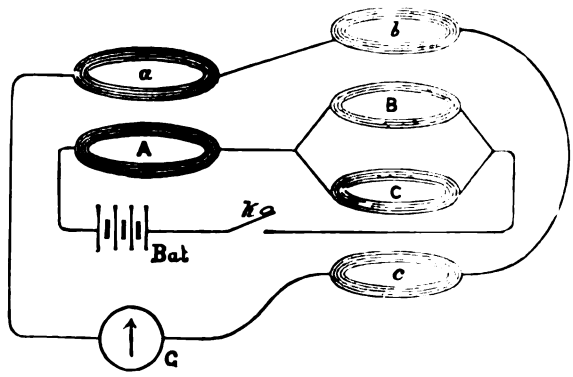

FIG. 13.

steady electromotive force E is applied to the primary, then if the position of battery and galvanometer are reversed, the application of the same electromotive force E to the secondary will give the same "throw" on the galvanometer now attached to the primary circuit, provided that the galvanometer and battery either have equal internal resistance or that their resistance is negligible in comparison with that of the coils. Hence we may assert that the induction of a circuit A upon B is the same as that of B upon A. For, if the resistances are R and S

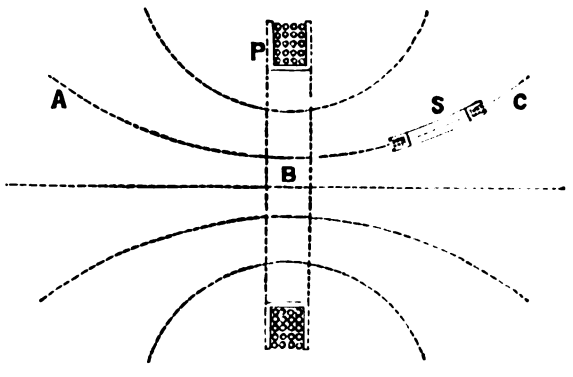

FIG. 14.

then we have seen that the total quantity Q of the secondary current is $\frac{M\,I}{S}$, when I is the steady value of the primary and M is the mutual inductance; but $I=\frac{E}{R}$, hence $Q=\frac{M\,E}{S\,R}$. If, then, the positions of battery and galvanometer are reversed, we get a quantity of induced current equal to $\frac{M\,E}{R\,S}$, which is the same as before. For any two coils it is possible to find a number of relative positions in which the interruption of a current in one produces no induced current in the other. In such cases the coils are said to be *conjugate* to each other. It is manifest that when in these positions the lines of induction produced by one coil do not pass through the other. It is possible to use one coil in this way to explore the field of another.

* Lenz. *Poggendorff's Annalen*, Bd. XXXI., p. 385, 1835.

† *See* Faraday, "Exp. Researches," Ser. II., § 193, *et seq.*; also for electrolytic circuits, *see* L. Hermann, *Pogg. Ann.*, 1871, p. 586.

‡ Felici, *Nuovo Cimento*, Vol. IX., 1859, p. 345, also *Ann. de Chimie* [3], Vol. XXXIV., 1852, p. 64.

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Let P be a primary coil and S be a small flat secondary coil, both being shown in section in Fig. 14. Then, if S is placed in a position conjugate to P, it will be found possible to move the coil S along a certain line A B C, maintaining the flat face of the coil always tangent to that line and so that in all these positions P and S are conjugate. It is evident that such a line is a line of induction of the coil P.

When one coil is in a conjugate position to the another, as far as regards inductive action they may be considered to be at an infinite distance apart. It follows, therefore, that if a coil is moved suddenly from a conjugate position to one not conjugate in the field of a primary traversed by a steady current, and then the primary current stopped at the instant of arriving at the second position, a galvanometer in the second circuit will have its needle jerked from one position of rest to another of rest, because the interruption of the current takes out of the circuit of the second coil just as many lines of induction due to the first coil as the motion from one position to the other put in.

(To be continued.)

LIGHTNING CONDUCTORS.—V.

BY DR. OLIVER LODGE.

(Continued from page 129.)

Application of Theory to the Last Recorded Experiments.

32. The agreement between theory and observation turned out so remarkably good in the last article that it encourages one to go into the matter a little further; for, although some of the precise numerical agreement is no doubt accidental, the numbers being easily changed one or two per cent. either way by differences in calculation, yet the discrepancies are well within errors of experiment, and their smallness seems distinctly to show that we are on the right tack, and have hold of the clue to a thorough understanding of these experiments.

But, concerning the value of μ, I was in considerable uncertainty, and chose two very different values merely to see how the results would come out. That they came out so very comparable with experiment was a matter of surprise to me, and was not expected till quite the end of the calculation, when I found it necessary to make the observations detailed in § 21 in order to interpret the spark-length indications.

In order to gain some information as to what value of μ was probable for the case under consideration, I wrote to our authority in magnetism, Prof. Ewing, asking him what value of μ was probable for an iron wire conveying a rapidly alternating current; and have just obtained from him a reply, which, being of general interest, I quote :—

"Next to nothing is known, I believe, about the value of μ for rapidly-alternating magnetic force. There is certainly a true magnetic viscosity; therefore μ for rapid alternation is certainly less than the static μ. How much less I have no definite idea. I think, however, that for such frequency of alter nation as occurs in a transformer, say, it is not much less. As to the static value, if your wire is annealed, it may be anything from 3,000 downwards to, say, 100, according to the particular value of $\mathfrak{H}$ at the place considered. If your wire is hard-drawn, it may be anything from about 500 downwards, according to the value of $\mathfrak{H}$. Take an example: a wire four millimetres in diameter, carrying 10 amperes, $\mathfrak{H}$ at the circumference will then be 10 C.-G.-S. This in an annealed wire would make $\mathfrak{B} = 13{,}000$, giving $\mu = 1{,}300$, about. In a hard-drawn wire μ for the same force might be about 500. At points nearer the axis, where $\mathfrak{H}$ is less, μ would (in the soft wire) be at first somewhat greater, and then less as you go nearer still to the axis. I should say that for soft wire $\mu = 1{,}000$ would be a fair average value, and for a hard wire $\mu = 300$ or 400."

33. It will be seen that he suggests a probable value intermediate between the extreme values I had previously made the calculation for; and that for the wires used $\mu = 400$ is a likely value for oscillations such as occur in transformers. But then these oscillations are only a hundred or two per second. Neither Prof. Ewing nor any one else is able to say what the value of μ will be for currents alternating at the rate of a quarter million per second. It would naturally occur to anyone that my experiments themselves should, when calculated out, be able to furnish the appropriate value of μ; and so I hope they will, but they cannot give a value at all closely, because an enormous difference in μ makes but little difference in the length of the B spark. The table printed last week shows that it makes but little difference, at least for cases when the second approximation is easily applicable; and a further theoretical discussion of the point brings out the same thing. There is this advantage about the fact, however, that it is not necessary to know the value of μ at all closely in order to make calculations. It may be asked why I do not determine μ for the particular wires used by direct experiment. It would be easy to determine the μ appropriate to steady longitudinal magnetisation, but this has no connection whatever with the μ appropriate to magnetisation in concentric cylinders alternating hundreds of thousands of times a second. *A priori* one could not say that for such a case as this μ is any greater than unity, but I hope that the experiments will enable us to pronounce on this point one way or another.

I may say that in writing these articles I have not done the calculations beforehand. I am making them as I go along, so as to test the theory by the facts whenever we have data sufficient to make an application of theory possible. The agreement so far found is sufficiently encouraging to make us willing to write out the theory a little more fully, so as to investigate all the circumstances on which the length of the spark alternative to a given conductor in a given circuit depends.

Second Approximation Theory Further Worked Out.

34. In § 4 a general notion of what is necessary for the second approximation to the alternative spark length is suggested, but it is not worked out in that first article. Now that we have a case for which it seems very clearly to apply we must proceed to work it out further.

The principal effect of resistance is the increase of impedance; the effect next in importance is the damping out of the vibrations. It being tolerably certain that the current must rise to a maximum before a critical B spark can occur, a quarter period, or $\frac{\pi}{2n}$, has to elapse between the A and the B spark. Hence the potential available for the B spark is (*see* § 2)

$$V = P_0 C_1 e^{-\frac{\pi m}{2n}} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

Now,
$$C_1 = \frac{V_0}{n(L + L_0)} = \frac{V_0}{p + p_0}, \text{ say,} \quad . \quad . \quad (10)$$

Hence,
$$\frac{V}{V_0} = \frac{P_0}{p + p_0} e^{-\frac{\pi m}{2n}} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

So, if we neglect damping, the ratio of the B spark to the A spark is as the total impedance of the alternative path is to the inertia part of the impedance of the whole circuit.

35. The first approximation, § 3, equation (4), gave us for the ratio of the two sparks

$$\frac{p_0}{p + p_0}$$

The second approximation, without damping, gives us

$$\frac{P_0}{p + p_0};$$

whose numerator contains not only the inertia part of the impedance of the alternate path, but the resistance part as well.

Suppose we call the inertia part of impedance "inertia" simply; and the resistance part let us call "throttling," so that (impedance)^2 = (inertia)^2 + (throttling)^2.

The throttling of the whole circuit write

$$R_0 + R = \sqrt{n}\{\sqrt{(\tfrac{1}{2} l_0 \mu_0 r_0)} + \sqrt{(\tfrac{1}{2} l \mu r)}\} = (a + b)\sqrt{n}, \quad . \quad (12)$$

where $a^2 = \frac{1}{2} l_0 \mu_0 r_0$, and is proportional to both the magnetic permeability and the ordinary resistance of the alternative path; while b^2 represents the same thing for the rest of the circuit.

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We have also the equations,

$$P_0^2 = p_0^2 + R_0^2 = n^2 L_0^2 + n a^2 \quad . \quad . \quad . \quad (13)$$

$$m^2 + n^2 = \frac{1}{S(L+L_0)} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$\frac{m}{n} = \frac{R+R_0}{2p} = \frac{a+b}{2\sqrt{n(L+L_0)}} \quad . \quad . \quad . \quad (15)$$

It is cumbersome and unnecessary to combine all these equations with absolute accuracy; but quite inappreciable error will be made by using the approximations

$$n = \frac{1}{\sqrt{\{S(L+L_0)\}}} - \frac{(a+b)^2}{8(L+L_0)^2} \quad . \quad . \quad (16)$$

$$P_0 = n\sqrt{(L_0^2 + a^2\sqrt{S(L+L_0)})} \quad . \quad . \quad (17)$$

and

$$\frac{m}{n} = \frac{(a+b)S^{\frac{1}{2}}}{2(L+L_0)^{\frac{1}{2}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (18)$$

Hence,

$$\frac{V}{V_0} = \frac{L_0}{L+L_0}\sqrt{\left\{1 + \frac{a^2}{L_0^2}\sqrt{S(L+L_0)}\right\}} e^{-\frac{\pi(a+b)S^{\frac{1}{2}}}{4(L+L_0)^{\frac{1}{2}}}} \quad (19)$$

This clearly shows the relation of the first approximation (the term outside the square root) to the second. The smaller the capacity of the condenser (other things being the same), the better serves the first approximation.

36. By means of this formula, it is easy to see how the ratio of the B spark to the A spark varies with the different arbitrary variables, L, L_0, S, a, and b.

Iron or Lead versus Copper.

The thing which most interests us is to examine how the B spark depends upon the resistance and magnetic properties of the alternative path—that is, how it varies with a, since $a = \sqrt{(\frac{1}{2} l_0 \mu_0 r_0)}$.

So take logarithms of (19) and differentiate, abbreviating

$$\sqrt{S(L+L_0)} \text{ to } \frac{1}{n};$$

then

$$\frac{1}{V}\cdot\frac{dV}{da} = \frac{a}{n L_0^2 + a^2} - \frac{\pi}{4(L+L_0)\sqrt{n}} \quad . \quad . \quad (20)$$

This clearly shows that when the alternative path is short, $\frac{dV}{da}$ is negative, and that hence the B spark is shortened by an increase in either its resistance or magnetic susceptibility; but that, as a increases, $\frac{dV}{da}$ passes through an insensitive stage, and ultimately becomes positive. When this is the case, the length of the B spark is increased by increasing r or μ.

The intermediate insensitive condition $\frac{dV}{da} = 0$ is attained when

$$a^2 = n\left\{\frac{4}{\pi^2}(L+L_0)^2 - L_0^2\right\} \quad . \quad . \quad . \quad (21)$$

that is, approximately, when

$$P_0 = \frac{2}{\pi}(p+p_0) \quad . \quad . \quad . \quad . \quad (22)$$

or, in other words, when the undamped potential available for the B spark is about two-thirds that available for the A spark.

Under these circumstances (which are very probable ones) a change in the material of the alternative path from copper to iron or lead makes hardly any difference.

The statement (21) for the insensitive condition may be also written, approximately,

$$R_0^2 = \frac{4}{\pi^2}\left(p_0 + p\right)^2 - p_0^2 \quad . \quad . \quad . \quad . \quad (23)$$

If the throttling of the alternative path is greater than the square root of the difference of the squares of $\frac{2}{\pi}$ times the inertia of the whole circuit and of the inertia of the alternative path, then a further increase in its r or μ will diminish its efficacy as an alternative path; but so long as the throttling is kept less than the above value, then the worse a conductor, or the more magnetic its substance, the better an alternative path will it afford.

Thus, the apparently abnormal fact that under certain circumstances thin iron serves as a better alternative path than thick copper (actually *because* it has a higher resistance and a higher value of μ, and thereby damps out the vibration sooner) is fully explained; and the circumstances under which iron ceases to be better and becomes worse than copper are completely specified.

(To be continued.)

THE WESTINGHOUSE COMPANY.

(Continued from page 131.)

The central lighting station at East Liberty, Pennsylvania, is considered a "model installation" of the Westinghouse Company, and is illustrated in the adjoining engravings. The following description is furnished by the company:—

"The arrangement of the station is clearly indicated. It is a substantial but inexpensive one-story building of brick, containing the offices of the company and the store room for material in addition to the dynamo and boiler room. The plant at present has an aggregate capacity of about 8,000 lights. Dynamos and engines are on the same floor, every part of which is constantly under the eye of a single attendant. Both engines and dynamos stand on brick foundations, the floor itself being of cement. Each engine is belted direct to its own dynamo, no power being wasted in transmission, and the subdivision into units enables the wide fluctuations of load to be met by stopping and starting each engine and dynamo as needed, thus operating the whole station under the highest possible economical conditions at any moment. The steam pipe is brought along the engine room overhead, and the engines exhaust into a main laid in a covered trench underneath the floor, every part being accessible. All drips and overflows are run into a sewer. Two exciters are provided, as shown on the left of the dynamo room, each adequate to supply current to the entire station, and each driven independently by its own engine. But one engine and exciter is, therefore, run at any time, the other standing ready as a relay in emergency. Moreover, the position of the engines and exciters is such that, by changing a belt, either engine can drive either exciter, and thus the chance of possible stoppage is reduced fourfold. We regard this latter arrangement as representing the best possible engineering, and would strongly urge it upon every station of any considerable magnitude. Two overhead travelling cranes traverse the whole length of the building over the engines and dynamos.

"In a station so arranged the labour is reduced to a minimum. With natural gas, of course, but one fireman is required, or firing with coal two firemen will be on duty in the first run of the evening, and one in the second run. But one attendant is required in the dynamo room at any time, the lightness of his duties permitting him to give all necessary attention to the engines, dynamos, exciters, and switch-board. The service from this station covers a very extended area, comprising the business portion of the city, which lies within an average distance of half a mile from the station, ramifying through an extended series of residence streets of the better class, and carrying one special line out as far as the distant suburb of Swissvale, the last lamp being at a distance of four miles and a-quarter from the dynamo."

One of the most interesting features of the Westinghouse system is their incandescent street-lighting plant, though it is one which is not suited to existing conditions in this country. As soon, however, as high candle-power incandescents of *moderately high voltage* are able to compete with arc lights in the matter of expense, then we believe that this system will afford the *beau ideal* of electric street lighting. In this arrangement 20 lamps, usually of 25 candle-power, and each taking 50 volts, are placed in series upon a loop line between the 1,000 volt mains, each lamp being shunted by an impedance coil. The coil is so proportioned that it takes a very small current while the lamp is burning, but if the filament breaks, *very nearly* the whole

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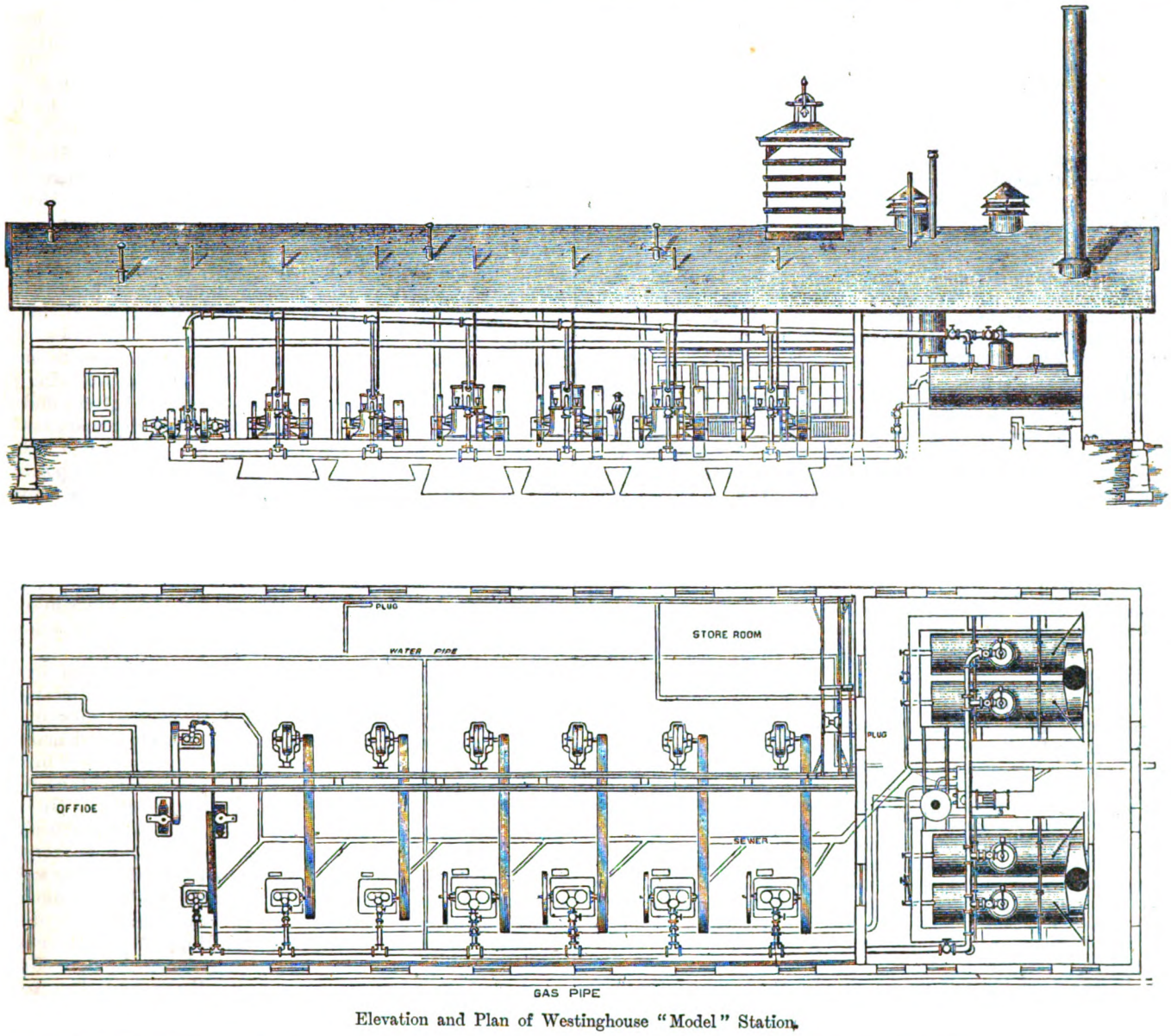
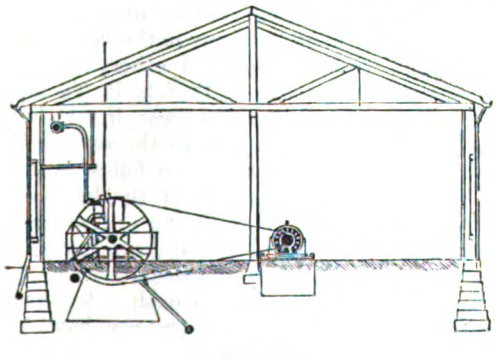


Elevation and Plan of Westinghouse "Model" Station.

current still passes through. Consequently the extinction of any one lamp has very little effect upon the rest, but the extinction of several tends to *diminish* the brilliancy of those remaining alight, an effect which it need hardly be said is the reverse of that attained in other multiple-series systems. This system, therefore, "not only consumes power



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in exact proportion to the total effective candle-power realised, but becomes self-protecting to the fullest extent." The flexibility of the alternate current is again exemplified by the fact that any desired economy may be attained in the leads by introducing a more or less considerable drop in potential, and compensating for this by placing 21 lamps in series on the loops nearest the station, and 19 in series on the more remote loops. If more convenient the loops may be taken off the general service mains, and may then leave from any point on one main and return at any point on the other. In Staten Island, N.Y., no less than 2,000 street lamps are served on this system from one station, the wires extending over a district 12 miles in length.

The Westinghouse Company recommend the exponents of its system to undertake the wiring of houses *free of charge*. This advice is scarcely likely to prove acceptable in this country; but the following remarks upon the lighting of shops may be read with advantage:—

"*The Lighting of Shops.*

"In commercial lighting, stores may be divided into three classes with respect to the degree of illumination. To the first class belong dry goods, drugs, hats and caps, and furnishing goods. To the second class belong crockery, groceries, boots and shoes. To the third class belong hardware and furniture. These are the leading branches of trade, and other lines may be judged of by their similarity in characteristics to the above.

"Taking the 16 candle-power lamp as a standard, high illumination will be secured by employing in the first class one lamp to every 100 square feet of floor surface, in the second class one lamp for every 150 feet, and the third class one lamp to every 200 square feet of floor surface. When lamps of larger candle-power are used—which, indeed, is preferable—the amount of floor space assigned to each lamp will be practically in proportion to its rated candle-power.

"Stores usually average from 18 to 22 feet in clear width. For convenience we may then place the 16 candle-power lamps in stores

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of the first-class in two rows over the counters, the lamps being 6ft. 6in. from the floor and 10ft. apart. In stores of the second-class the lamps should be 15ft. apart, and in those of the third-class 20ft. apart. In stores less than 15ft. in width, the most economical treatment as well as that which produces the best effect, is to place a single row of lamps in line through the centre of the store, the lamps being suspended 7ft. high and from 6ft. to 12ft. apart, according to the class to which the store belongs. Upon entering the store the eye of the customer sees all the lamps at a single glance, and the illumination appears more liberal than if the same number of lamps were placed in two rows and twice the distance apart.

"Practice has demonstrated, however, that a better general effect as well as economy in first cost is secured by the use of lamps of 50 or 75 candle-power either against the ceiling or at least as high as 10ft. from the floor. Such lamps should be backed with slightly concave or slightly convex opalescent reflectors, according as the nature of the goods requires a concentrated or diffused light. In stores of the first class these lamps are to be placed at intervals of 20ft., in the second class of 30ft., and in the third class of 40ft.

"These large lamps will always be placed in a single row down the centre of the store, except in those of extreme width. As a rule, the wider the store the higher the lamp should be placed. It is sometimes contended that a 16 candle-power lamp, hung low over the counters, and backed with a porcelain, or other shade, will give the best illumination for the sale of counter goods. This, if true at all, is limited to dry goods and fine wares requiring close inspection. Even with this class of goods, however, the large lamps placed high afford a better general diffusion of light more nearly approximating sunlight. The large lamp, moreover, produces a much greater general illuminating effect in the store. It throws its light upon the shelf, goods, and ceilings, getting the benefit of general reflection and diffusion in a manner which cannot be accomplished by the use of low-hung small lamps, the light of which is cut off from the upper shelves and ceilings altogether.

"A very important consideration in connection with the use of the large lamp is the fact that the first cost of interior wiring is considerably lessened by a reduction in the amount of labour in proportion to the lesser number of outlets, and by the saving in the first cost of lamps, sockets, and other material. The size of wire will be the same in each case for a given total candle-power, but the other material is greatly reduced in relative cost. Again, the use of small and low-hung lamps implies the use of a key socket to each lamp, and it is probable that the slight jar produced in turning the key may sometimes machanically fracture the filament of the lamp, especially when weakened by old age. When large lamps are used in or near the ceiling, the entire circuit is controlled by a branch switch remote from the lamps. The opening or closing of the switch, therefore, communicates no jar to the lamp, and its life is apparently prolonged.

"In laying out the interior wiring for a store, much good judgment can be displayed. In general terms, the main illumination of the body of the store is controlled by one switch, the show window illumination by another, and the watch lights by a third."

There are other features of great interest connected with the Westinghouse system, such as the Shallenberger meter* and the Tesla motor,† but as we are not at present in a position to add anything of value to the information which has already appeared in our columns, we now for the time being take leave of the subject.

REVIEWS.

Die Accumulatoren fur Elektricitat. By Dr. Edmund Hoppe. [Berlin: Julius Springer. 1888.]

Dr. Hoppe has produced a most interesting and readable book on that much belauded and equally well abused subject the secondary battery. It is written rather from the historical and scientific than from the practical point of view, and it is the more valuable in that the author does not appear to have any pet theories or fancies of his own, but gives a clear and well-digested account of other experimenters' work in a spirit of strict impartiality. That Dr. Hoppe does not altogether believe in the commercial battery man may be gathered from the quiet remark in the preface that "in the matter of accumulators, as in most things electro-technical, there has been much swindling," which is followed by another, "that manufaturers' tests are but seldom given in this book."

The first half of the work might have been aptly called a history of polarisation from the earliest times to the end of the Middle Ages. Beginning with the discovery of the fact by Ash and Humboldt, we have an excellent *résumé* of the work done by the early experimenters, such as Volta, Ritter, Davy, Grotthus, Faraday, &c., up to the later period when such work was mostly in German hands. This part of the book bears evidence of considerable research on the author's part, the references to old literature being copious, while from time to time are given lists of articles in various publications bearing on the subject in hand. Dr. Hoppe considers that all useful investigation on polarisation was for some twenty years turned into a wrong channel and wasted by Erman's "discovery" of unipolar induction. One can well imagine what a mystery such a phenomenon must have been to the scientific world with the scanty knowledge then at its disposal. Indeed, even with our present text-books there would probably be some strikingly original answers to an examination question such as this:—Explain the following phenomena. A wire connected to the + pole of a battery and also an earth wire are stuck into a piece of very dry soap, but not touching each other. The positive pole is then found to be at zero potential, and the negative pole at full negative potential. The same is repeated reversing the poles, with the converse results. Wires from both poles, but no earth wire, are now stuck into the soap, and this has no effect on the potential of the poles; but if the earth wire be now also stuck in, even quite close to the positive wire, the negative pole falls to zero, while the positive comes to full potential. Any examiner in search of useful misinformation might, we fancy, acquire a goodly store in the answers he would receive.

With the large amount of previous work shown by Dr. Hoppe in view, one feels the truth of the saying that most great modern discoveries are not invented, they grow, they are "in the air," and come to the front as soon as there is a demand for them. In fact, one might define the "first inventor" in these cases as the man who first shows the practicality of what previous investigators have shown the practicability. He by no means necessarily himself knocks the $b+e$ out of practicable—that is as often as not left to some subsequent worker—but merely shows that they *can* be removed. In this sense we may consider Faure as the "first inventor" of the accumulator, though all the scientific honour of the discovery is due to Planté, with whose investigations Dr. Hoppe begins the modern section of his book, under the heading of construction of accumulators. From Planté we come to Faure, and then to the long array of "inventors" and reinventors who have rushed to the Patent Office with their crude and often untested ideas. Amongst all this chaff we find, of course, the few grains of wheat which have survived to the present day, but they are lamentably few.

In this section there is a list of the German patents on accumulators (most of which are marked "lapsed"). It would add completeness to the book if those of other countries were given also; though, as the author remarks, in the case of most really valuable foreign ideas the German patent is applied for. The chapter on the chemistry of the lead accumulator will probably be read with as much interest as any in the book. The theories of Gladstone and Tribe, Aron, and others are given pretty fully, and finally the remarks of Prof. S. P. Thompson at the Society of Telegraph-Engineers last year, in which he applies the crucial test of the E.M.F. due to the various theories of action. Should anyone feel inclined to follow in his footsteps there will be found on p. 171 a table of the heats of combination of most of the compounds occurring in practice of Pb, H, O and S, besides those of several other components of possible batteries. The table is due to Naumann. The question of efficiency tests is gone into at some length. A page of matter and the integration of the tail of a curve are, however, scarcely necessary to show the inadvisability of draining a cell to its last drop of current in such tests. Two lines touching the consequent disintegration of the plates is all that is required, and more to the point. Dr. Hoppe very rightly stands out here for efficiency in watt—and not in ampere—hours. Results are still often given in the latter, because no doubt they sound so much nicer. There is one cell mentioned in this chapter, by the way, which gives *more* watt hours yet *less* kilogrammeters

* See *The Electrician*, September 7, 1888, p. 556.
† See *The Electrician*, June 15, 1888, p. 173.

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than another; whether the slip is Dr. Hoppe's or due to Mr. Fitzgerald, on whose authority the figures are given, we cannot say.

When Dr. Hoppe gets to purely practical matters, such as installation work, he is not quite so happy. He only devotes a few pages at the end to this subject, and for the sake of the goodness of the rest of his book let us hope he may be forgiven his sketch of an installation with plugs instead of switches and resistances between the batteries and lamps.

In future editions, which we have no doubt will be called for, we hope we shall find a full alphabetical index of matter instead of inventors' names only, as this is an important matter in what will, no doubt, become a standard work of reference; and in conclusion we heartily congratulate Dr. Hoppe on the successful way he has carried out his intention in the preface to "collect into one book all the scientific work on accumulators up to the present time."

The Elements of Electric Lighting, including Electric Generation Measurement, Storage, and Distribution By PHILIP ATKINSON, A.M., Ph.D. (New York: D. Van Nostrand, 1888.)

This book makes scarcely any pretension to rank as a scientific treatise, but aims at setting forth the foremost facts pertaining to electric lighting in plain language. In this the author may be said to have achieved a moderate degree of success, though his explanations of elementary theory, as, for instance, the relations between E.M.F., current, and resistance might easily be more simple without being less accurate. He describes a good many types of dynamos, and goes pretty fully into constructive details, although numerical relations are carefully avoided. All the continuous current machines alluded to are American—at least in origin—but the somewhat remarkable fact is brought out that the United States has hitherto produced only one alternating-current dynamo — the Westinghouse. The Siemens, Gordon, and Lontin dynamos, therefore, find a place in these pages; the machines of Ferranti, Mordey, and Kapp will doubtless find a place in the next edition. A fairly complete account of the Westinghouse system is given, with some capital drawings of transformers.

A short chapter is devoted to instruments in practical use for measuring current and E.M.F., and this is followed by a fairly good chapter entitled "Arc Lamps." A much greater space than usual is devoted to carbons, and the Liepmann process of manufacture (described in *The Electrician* of Nov. 18th, 1887) is dealt with at some length. The title of the chapter is, after all, somewhat of a misnomer, as only one arc lamp in practical use receives any mention. The chapter on incandescent lamps is written from the American point of view. It is true that nearly half a page is devoted to the "Swan Carbons," but not a word is said which would lead a novice to suppose that the priority of Edison had ever been challenged. The chapter on the Storage Battery is one of the best in the book, although it seems necessary to say that the chemical action which goes on in the cell is in all probability somewhat less simple in character than is here set forth. It is well known that in the Julien cell an alloy is used instead of pure lead. Dr. Atkinson says that this alloy consists of 94·5 per cent. of lead, 4·2 per cent. antimony, and 1·3 per cent. mercury; we think, however, that this recipe is only to be found in the patent specification, and if we are not mistaken, no mercury is actually employed in practice. A wide field for research exists in the discovery of alloys suitable for secondary battery plates, but, unfortunately, very little theoretical knowledge is available to guide the experimenter.

The author has a good deal to say about "electricity as a mode of molecular motion;" but in a book of this character the subject is, of course, treated from a purely physical standpoint, and, hence, that class of difficulty which appeals to Thomson, Lodge, or Heaviside does not present itself. The chapter in question contains one extraordinary slip to which it seems desirable to call attention. The author in considering thermo-electric action writes as follows (the italics are our own):—"The capacity of bismuth for heat known as its specific heat is 0·03, and that of antimony 0·051 . . . . *and the temperature of each when heated or cooled from the same source varies in the inverse ratio of its specific heat; hence, at the heated junction the temperature of the bismuth rises above that of the antimony, and at the cooled junction falls below it.*" We are at a loss to account for so competent a physicist as Dr. Atkinson falling into such a very palpable error. It is scarcely necessary to explain that when any number of bodies are heated or cooled by radiation the ultimate temperature which each assumes depends upon its own radiative power, and not upon its specific heat. The latter only determines the *quantity* of heat to be absorbed or radiated—and hence the *time* necessary—before the final temperature is acquired.

If there be any connection between specific heat and thermo-electric power it is probably of a very recondite nature, and, anyhow, it is safe to say that it is not of the kind assumed by the author. There are other passages in this chapter which lead us to think that pure science is not the author's strong point, and the book would be decidedly improved by its exclusion from subsequent editions.

We may remark, in conclusion, that the work gives a fairly comprehensive survey of the "paraphernalia" of electric lighting, and may be usefully read by anyone who is in want of general rather than theoretical or technical information on the subject.

Electric Bells, and all About Them. By G. R. BOTTONE. (London: Whittaker and Co., 1889.)

This handbook professes to be "a practical book for practical men," and the claim is one which we need have no hesitation in endorsing. Anyone desirous of undertaking the practical work of electric bell fitting will find here everything, or *nearly* everything, he needs to know. On the first page he learns something about the Greek word for "amber," and on the last he is earnestly cautioned to keep his binding screws well tightened up. The intermediate pages are devoted to the detailed consideration of various types of batteries, bells, indicators, switches, pushes, and relays, concluding with a useful chapter on "Wiring, connecting up, and localising faults."

In the chapter on batteries we could perhaps have spared the sections devoted to Smee's and other cells, which no one would ever dream of using for the purpose. It would also be useful if the author had given some indication of the minimum current required to work the various apparatus described. The number and size of cells is always a difficulty to the inexperienced bell-hanger.

In conclusion, we may remark that this little book will be welcomed by none more heartily than by the electrical engineers. It is a well-known fact that the members of that profession are nearly always looked upon more or less as frauds by their private friends and acquaintances owing to their manifest and deplorable ignorance about the important subject with which this work so ably deals.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, December 14th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "The 26-Knot Spanish Torpedo-Boat 'Ariéte.'" By JULIAN KING-SALTER, Stud. Inst. C.E.

MONDAY, December 17th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture. "Light and Colour." By Capt. W. de W. ABNEY, C.B., F.R.S. (Lecture IV.)

TUESDAY, December 18th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "The Friction of Locomotive Slide Valves." By J. A. F. ASPINALL, M.I.C.E.

WEDNESDAY, December 19th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting, at the Institution of Civil Engineers.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Standards of Light." By W. J. DIBDIN, F.I.C., F.C.S.

THURSDAY, December 20th.

SOCIETY OF TELEGRAPH-ENGINEERS.

5 p.m. Special General Meeting of Members at No. 4, The Sanctuary, to confirm the resolutions respecting the change of title.

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The Electrician.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.		6 months.		12 months.	
	s.	d.	s.	d.	s.	d.
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Within Postal Union	6	6	12	6	24	0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7	6	14	6	28	0
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THE DIRECTORY FOR 1889 IS IN PREPARATION,

And new names and addresses are now being received.

CONTENTS OF THE CURRENT NUMBER.

Notes 155
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 160
Lightning Conductors.—V. By Dr. Oliver Lodge. Continued 161
The Westinghouse Company. Illustrated. Continued 162
Reviews 164
Meetings of Scientific Societies. 165
The International Electrical Congress of 1889 166
The Society of Telegraph Engineers and Electricians 167
The Reckenzaun Storage Battery and Electric Tramcar. Illustrated 168
Physical Society—
"A Modification of the Ordinary Method of Determining Electro-Magnetic Capacity. Illustrated 169
The "Daft" Electric Locomotive. Illustrated 170
American Notes 170
Notes from Vienna 172
Notes from Scandinavia 172
Correspondence 173
Provisional Programme of the International Electrical Congress of 1889 174
Parliamentary Notices under the Electric Lighting Acts... 175
Legal Intelligence—
Edison and Swan Electric Light Company *v.* Holland and Others 175
King, Brown and Co. *v.* The Anglo-American Brush Electric Light Corporation. Ill. 177
United Telephone Company *v.* Ericsson-Bell Telephone Company 181
United Telephone Company *v.* Edward Paterson 181
Companies' Meetings, &c.—
Swan United Electric Light Company 181
Woodhouse and Rawson 181
City Notes, &c. 181
Companies' Share List 182

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SPECIAL NOTICE.

With the next number of "THE ELECTRICIAN" will be published as an Extra Supplement a Steel Portrait Engraving of Sir WILLIAM THOMSON, F.R.S., &c., &c., &c., the newly-elected PRESIDENT of the INSTITUTION OF ELECTRICAL ENGINEERS. This portrait is one of the Series which has appeared in the pages of "THE ELECTRICIAN," and which will be continued as occasion may seem to warrant.

THE INTERNATIONAL ELECTRICAL CONGRESS OF 1889.

When the *Société Internationale des Electriciens* (so-called) announced its intention of recommending the Government of France to convene an International Congress of Electricians in connection with the forthcoming Exhibition, we did not feel moved to do more than express a qualified approval. The avowed object and the chief duty of the proposed Congress, as originally set forth, were to "continue the labours" of the Congresses held in 1881 and 1884. But that there exists any pressing need of an International conclave for the purpose indicated we have still to discover. It must, moreover, be admitted that if the Congress of 1889 were strictly confined to the completion or revision of the work of its predecessors, its duties would not be of a very onerous character, nor need its labours be unduly prolonged. It might, if it so pleased, give its august sanction to the use of the term *watt* as the electrical unit of power. That, we believe, is the only electrical unit in common use which has not already received its credentials from this source, and we do not see why it is not as well entitled as its brethren to all the dignity of "legal" and formal recognition. The baptism and definition of the unit of self-induction might also perhaps profitably occupy the attention of the Congress. Then there is the question of the determination

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of the ohm in terms of the mercury standard. While we do not think that a change in the actual definition of the legal ohm would meet with any enthusiastic welcome—nor could it, indeed, be enforced except with the greatest difficulty and in the teeth of a determined opposition—yet it might, nevertheless, be worth while to take advantage of the Congress to obtain an authoritative expression of opinion as to the value at present most probable. That this value lies somewhere between 106·2c. and 106·3c. is already pretty well known.

Another question of considerable importance, and of the greatest difficulty, is that of a practical standard for the unit of light. The Congress of 1884 accepted M. VIOLLE'S proposal, and defined the unit of light as that given by one square centimetre of platinum at its melting temperature. But although this idea has been ingeniously realised by Dr. WERNER SIEMENS, yet we are not aware that it is at all used in practice, and, in fact, most people have only the vaguest idea of its relation to the standard candle. This latter standard we regard as an interesting case of "reversion to type" as when, in the pre-scientific ages, the length of a Royal arm gave us our yard measure. Seeing that a good deal of excellent work has been done in photometry since the date of the last Congress, and that more than one "standard" has since been proposed—notably the "pentane standard"—we are decidedly of opinion that the subject should be discussed *de novo*. Lightning conductors and earth currents were the only remaining subjects upon which the earlier Congresses passed resolutions; and these were only in the nature of "pious opinions."

In addition to these several topics there are, doubtless, others —some of an academic and some of a practical character—which might be discussed with more or less advantage. In the former category we may name the Theory of Dimensions, which has lately been occupying the attention of our Physical Society, and which undoubtedly stands in need of careful reconsideration. An attempted reformation in this direction would certainly be more effective if it bore the *imprimatur* of an International Congress. In practical affairs it is possible—though we make the suggestion with some hesitation—that the Congress might do well to undertake an investigation of the conditions of personal safety with high-tension currents, both alternating and direct. Although it will be seen that we are not now attempting to indicate the limits within which we think the work of the Congress should be restricted, we may, nevertheless, hazard the opinion that it would be a decided mistake if any endeavour were made to travel very much further afield, and especially if it were proposed to adjudicate upon, or even to discuss, the relative merits of the apparatus and methods connected with the commercial applications of electricity.

Nevertheless, this is exactly what is now proposed to be done. On another page will be found the official programme of the "Preparatory Committee" of French Electricians, whose appointment by the Minister of Commerce we noted some time since. Although we are sincerely sorry to say so, we cannot help thinking that this programme is, to say the least, not a judicious one. In the first place, notwithstanding the division into six sections, it is far too long. It would certainly be impossible to do justice to one-half of the questions proposed in any reasonable space of time. But this is not by any means the worst feature. From our point of view the subjects selected for discussion are in very many cases wholly unsuited for treatment by a body whose functions are—or have hitherto been supposed to be—of a legislative character. It seems to us that the Preparatory Committee has confounded the functions of the Congress with those of the Jury of the Exhibition. If the International Congress of Electricians is to discuss the different methods of automatic regulation of dynamos we shall presently be seeing advertisements of "the automatic regulator, as recommended by the International Congress." Alternate-current motors may *possibly* be a legitimate subject for their attention—though even here we are doubtful—but the comparison which is invited between the relative advantages of alternating and continuous currents is, in our opinion, quite out of place. Most of the other questions proposed in this section—such, for instance, as the efficiency of dynamos and the "possibility of constructing very powerful machines"—seem to us equally unsuitable. Objections of a similar character apply more or less all through the programme. An International Congress of Electricians may perhaps be allowed to say something about International Telephone lines, though the question is really a political one; but why it should be expected to devote its attention to the subject of making joints in telegraph wires, and "how many telephone connections can be made per hour by a single operator," we are at a loss to imagine.

There does not seem to be any reason why a series of meetings for the free discussion of various electrical topics should not be held during the Exhibition, and we are far from saying that an exchange of views between the practical electricians of different countries would not produce useful results. But to indiscriminately confound under the style and title of an International Congress the discussion of mere points of technical or commercial detail, with the deliberations of the leaders of scientific thought upon that limited number of far-reaching questions upon which the agreement of the whole civilised world is really desirable seems to be equally unnecessary and unwise. We most sincerely hope for the success of the Electrical Section of the Paris Exhibition of 1889, and also of the Electrical Congress; but to that end we strongly advise that an amended programme be prepared.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The Annual General Meeting of this Society was held last night at the Institute of Civil Engineers, Great George-street, Westminster, when the undermentioned officers and council for the ensuing year were elected:—

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William Crookes, F.R.S. | Alexander Siemens.

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F. H. Webb.

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THE RECKENZAUN STORAGE BATTERY AND ELECTRIC TRAMCAR.

The design of storage batteries for the purpose of electric traction has occupied Mr. Reckenzaun's attention for a very considerable period, and he has conducted a long series of costly experiments in order to determine the most suitable and practical method of construction. In writing last week on the subject of battery traction we promised at an early date to bring before our readers some results which, so far as we have had opportunity of observing, have impressed us as being distinctly the best hitherto attained. This promise we now fulfil in describing the Reckenzaun battery; and we cannot justify the view we have taken more conclusively than by stating that a Reckenzaun plate in any stage of its formation may be bent to and fro or doubled upon itself without any loss, or any trace of loss, of paste. Anyone who knows how carefully plates of ordinary design have to be handled, and how fatal is any bending or deformation of the plate, will appreciate the significance of this feature in connection with a cell designed not only for rapid variations of output but also to withstand the continual jolting and frequent handling which is inseparable from tramcar work.

The expansion of the active material has been the cause of most of the trouble in storage cells, and this cannot be prevented; it is a necessary result of the oxidation of metals, and no amount of mechanical strength in the grids can stop it. In the early days it was thought that by making parts of the grids thicker and by providing numerous insulating studs or separators between the plates, this tendency to rapid destruction could be prevented. But it was found that stout ribs only aggravate the evil, because when the active material expanded, it stretched the thinner ribs more than the thick ones, with the natural result of "buckling" the plate, and the least movement out of its normal line caused the paste to crack and tumble out in halves. M. Julien and others make use of alloys of lead and antimony, which give a very stiff grid. This answers very well in cells where comparatively low current rates are used, but in thin plates for tramcars it was found that though the grid remained intact, the paste was bound to split and crack in the endeavour to found room for its own increasing volume.

Numerous attempts have been made to cast or roll grids the holes of which were intended to offer concave sides for the better retention of the material, but these processes were attended with great difficulties and expense, and the results obtained do not seem to have come up to the expectations. During the early part of the year 1884, Mr. Reckenzaun struck out a new line of study with two objects in view, viz.:—Firstly, to ascertain whether it would be possible to produce compound plates without providing perforated supports, grids, corrugations, reticulated or other frames. For this purpose he tried various methods of casting pieces of oxide of lead together with lead, and he also tried to cast metallic lead round pellets of oxides. Having satisfied himself that this was possible, the next series of experiments were directed to discover whether and to what extent the *shape* of the oxide entered into the question of ultimate success, and it was found that not only the shape of the oxide, but also the shape of the supporting material influenced the final results of secondary battery plates. It is not difficult to understand that these experiments necessarily extended over a long period, and necessitated the most careful observations to note the relative effects of different arrangements. This process of evolution, however, had the effect of convincing Mr. Reckenzaun of the following facts:—First, cylinders of small diameter and comparatively great length are least liable to distortion, because they expand principally in the direction of their own axis, which is parallel to the surface of the plate; secondly, the minute expansion in the direction of their diameter merely causes more effective contact with the surrounding metal; thirdly, the metal which is cast round the cylinders must be of uniform thickness, and of soft (that is, pure) lead, so as to offer little resistance to elongation.

Some plates of this description which are said to have been in constant use for three years we have recently examined. We have bent these, rolled them up into the form of a cylinder, and unrolled them again without disturbing the active material, or observing any scaling of the plates. The construction is illustrated in the accompanying figure (Fig. 1).

The porous cylinders are $\frac{3}{16}$in. in diameter, and about $1\frac{1}{2}$in. long. After being formed in a mould they are put into cavities in a cast iron chill $\frac{1}{4}$in. distant from centre to centre, and the molten lead is poured in, producing a substantial looking plate. The metallic part of the plate is only $\frac{1}{8}$in. thick, so that the cylinders protrude on both sides, and thus offer a large active surface to the electrolyte.

At the works of Messrs. Stephens, Smith and Co., at Millwall, there is now awaiting shipment an electric tramcar, fitted with these cells, and with the worm and wheel gearing with which Mr. Reckenzaun's name is connected. This car has been built to the order of Messrs. Booth, Ellson and Co., of Melbourne, and it is intended for the Sandhurst and Eaglehawk Tramway, in the City of Melbourne. The car itself is of the best American 2-horse pattern, and was built by Mr. George Milnes, of Birkenhead. The body is so constructed that it can be taken apart for shipment. The machinery consists of two 8 horse-power Reckenzaun motors, each driving an axle through the medium of worm gearing. The motors are collectively capable of yielding 24 horse-power, if required, without undue heating, and they will have to propel the car over gradients of 1 in 20 of considerable length. We have seen this car running and starting on such a grade with perfect ease. The field-magnet coils of each motor are divided into four equal sections, and their ends are joined to a commutator at each platform. By turning this commutator these coils can be automatically coupled in a

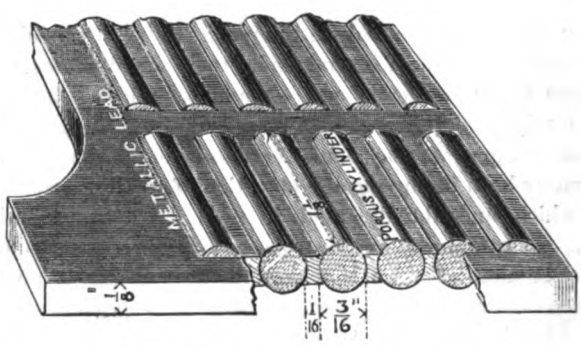

FIG. 1.—The Reckenzaum Storage Battery Plate.

variety of ways; that is to say, the resistances of the motor circuit are varied by coupling the coils all in series, or all in parallel, or by either of the two other intermediate arrangements. Four different speeds and powers are thereby obtained, without interfering with the coupling of the cells. The motors are very compact, weighing 600lb., and measuring 26in. long over the bearings, 22in. wide, and 12in. high. There is ample space for this machine under the floor of the car, leaving 12in. clear between the roadway and the underside of the motor frames. Each motor is supported on a triangular wrought-iron frame, resting on three bearings upon the axles. This arrangement allows a free movement of the axles on uneven rails, without causing undue friction on the bearings of the frame. The spindle of each motor is, moreover, attached to the worm by means of a flexible coupling, so that all the bearings can get considerably out of line without in any way interfering with the driving gear.

The steel worms have a pitch of 45 degrees, so that they can be driven backwards by the wheels; the car can therefore run down even a slight grade (of 1 in 100) by gravity alone. The worm-wheels are of phosphor bronze, and run within a dust-tight cast-iron casing, and this casing contains a quantity of oil, which lubricates the gear automatically without attention for weeks. The top of the casing forms two thrust bearings for the worm to revolve in. We take it for granted that if at ordinary speeds this gearing will give an efficiency as high as 85 per cent., then its positive action, absolute silence, strength, and compact shape render it particularly suitable for street car traction. The usual hand-brakes are used for stopping and going down grades.

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The storage cells are 72 in number, each made up of 17 plates, giving a capacity of 160 ampere hours. The cells are placed on long boards under the seats. These boards are on rollers, and can be readily drawn out through doors at either end of the car. The cells, with trays, terminals, and all necessary fittings, weigh about two tons. The car, when loaded with 30 passengers, weighs about 7½ tons. It requires about five electrical horse-power, with the full load, to run on the level road at seven to eight miles an hour, and nearly four times that power on a grade of 5 per cent. rise. The car is beautifully finished, both inside and out, and is lit by incandescent lamps.

PHYSICAL SOCIETY.

At the meeting of this Society, held on the 8th inst., the President (Prof. A. W. Reinold) in the chair, Dr. WAGHORNE read a note on

"A Modification of the Ordinary Method of Determining Electro-Magnetic Capacity."

The author stated that the object of his proposed method was to enable the capacity of a condenser to be determined with a fair amount of accuracy, without the use of costly apparatus. The ordinary well-known method is to charge the condenser to a definite potential by means of a battery, discharge through a ballistic galvanometer, and observe the throw d_1. Then observe the steady deflection d_2 when the same battery is connected in series with the galvanometer and an added resistance, bringing the total resistance of the circuit up to a value R, such that d_2 may not differ greatly from d_1. If t is the time of a complete swing of the needle, the capacity in farads will be

$$F = \frac{t\, d_1}{2\pi\, R\, d_2}.$$

To obtain accurate results d_1 must be not the observed throw, but, owing to the effect of damping, this throw increased in a certain ratio determined from the logarithmic decrement, which must, therefore, be found. Secondly, the value of R must be extremely high to make d_1 and d_2 nearly equal. Thirdly, owing to the shortness and consequent stiffness of the suspending fibre, and the effect of this being greater on the throw than on the steady deflection, the value of d_1, corrected for damping, will still be too small relatively to d_2, and must be further corrected by means of torsion observations.

Prof. Ayrton had suggested obviating the necessity of so high a resistance by using only a known fraction of the E.M.F. of the battery when determining the steady deflection, and to diminish as far as possible the error arising from torsion the author had used Mr. Vernon Boys's quartz fibres. The author, however, proposed to overcome the difficulty more completely by reading in the second case the deflection on closing the circuit, which would be double the permanent deflection if there were no damping, instead of reading the permanent deflection directly. The damping, however, in the two cases will be so nearly equal that it is not necessary to allow for it. With this method resistance coils of from 1,000 to 10,000 ohms may be used in conjunction with any suitable sensitive galvanometer, which need not, however, be specially constructed for ballastic experiment. A Pohl commutator or rocking key is very convenient for making a series of observations of the two throws in rapid succession.

The slightly modified form of this commutator adopted by the author is shown in the diagram, which represents the arrangement adopted in the experiments. Let a be the resistance of that portion of the resistance coils to which the condenser terminal is connected, and b the resistance of the portion to which the terminals carrying the steady current is connected.

Then if d_2 is the deflection on closing the circuit, we have, assuming the damping to be the same in each case,

$$F = \frac{t\, d_1\, b}{\pi\, R\, d_2\, a}.$$

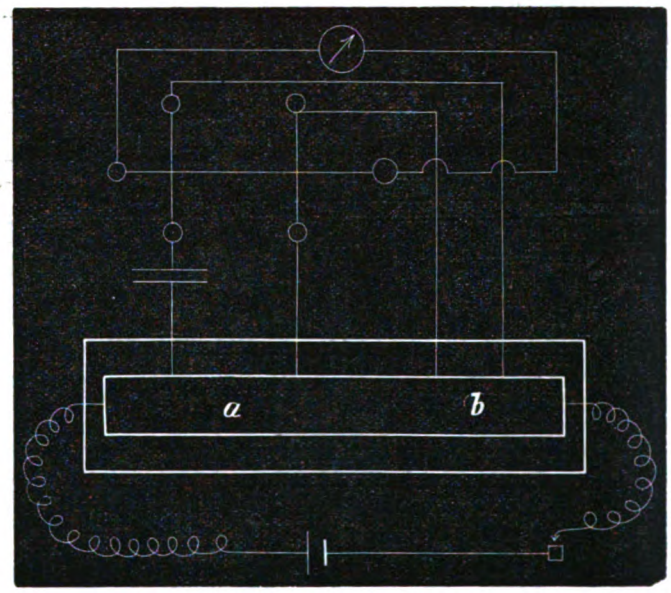
It is not necessary to insert any resistance into the permanent circuit except that of the galvanometer, but the value of this must be known at the temperature of observation.

The author affirmed that in any galvanometer in any way suitable for ballistic purposes, the error arising from difference in damping on the open and closed circuit would be negligible, and he stated that in the case of a galvanometer of 2,000 ohms resistance, which he had been using, the logarithmic decrement was ·0415 on open circuit and ·0428 on closed circuit, giving an error of only 1 in 2,000. He pointed out that the error arising from the stiffness of the fibre was not entirely eliminated as the swing was half a period on closing the circuit, and only a quarter period on breaking it. It was, however, reduced to a very small amount. The period of swing of the needle should not be less than two seconds, as the effects of self-induction on closing the circuit would then become sensible. The author states that he is able to obtain an accuracy within from a half to a quarter per cent.

Prof. S. P. THOMPSON observed that a point which was often lost sight of was the necessity of determining the capacity of the key in measuring the capacities of small condensers. It was advisable on this account to adopt such an arrangement as to make the electrostatic capacity of the key as small as possible.

Prof. AYRTON considered that any method which made it unnecessary to determine the logarithmic decrement would be valuable. He had a faint recollection of trying, in conjunction with Prof. PERRY, a somewhat similar method when in Japan. He believed, however, that it was in some experiments for determining the capacities of substances likely to act as electrolytes, and give an E.M.F. of polarisation.

Mr. SUMPNER expressed surprise at hearing that in the case of the galvanometer used by the author the damping was nearly the same on open and on closed circuit respectively. In the case of a Thomson high-resistance astatic galvanometer with which he was familiar, the logarithmic decrement on open circuit was only about half its value on closed circuit. In this case, therefore, the air damping formed about half of the total effect, while in the case mentioned by the author it would appear that the air damping was practically the whole effect. It would, therefore, be necessary to calculate and allow for logarithmic decrement.



Prof. AYRTON said that Mr. Sumpner's remarks had recalled to his memory that this was exactly the difficulty which they had met with, and which had prevented them from paying further attention to the method. The fact, however, that in spite of neglecting the difference in the logarithmic decrement, the author had succeeded in obtaining results of an accuracy within half or a quarter per cent., appeared to prove that the method was a good one.

Dr. WAGHORNE, in reply, observed that a galvanometer, in which the damping was considerable, would not be suitable, as it would be difficult to determine the time of swing with accuracy. He thought that the logarithmic decrement, having nearly the same value on closed and open circuit in the case of his galvanometer was probably due, in part at least, to the induced currents in the metal framework of the galvanometer when the circuit was broken. The method he explained was intended for the determination of moderately large capacities; only he thought that the elimination of the torsional correction was of more importance than obviating the necessity of determining the logarithmic decrement.

The PRESIDENT (Prof. Reinold), in conclusion, observed that he considered this a useful modification of the ordinary method, as it enabled the capacities of condensers of from half a microfarad to a microfarad in capacity to be directly measured with as great accuracy as could be obtained by comparison with a standard condenser, thus obviating the necessity of an accurate standard condenser.

The Patent, Designs, and Trade Marks Bill.—This Bill was read a third time in the House of Commons on Thursday last week, and on Tuesday the Commons' amendments were agreed to in the House of Lords.

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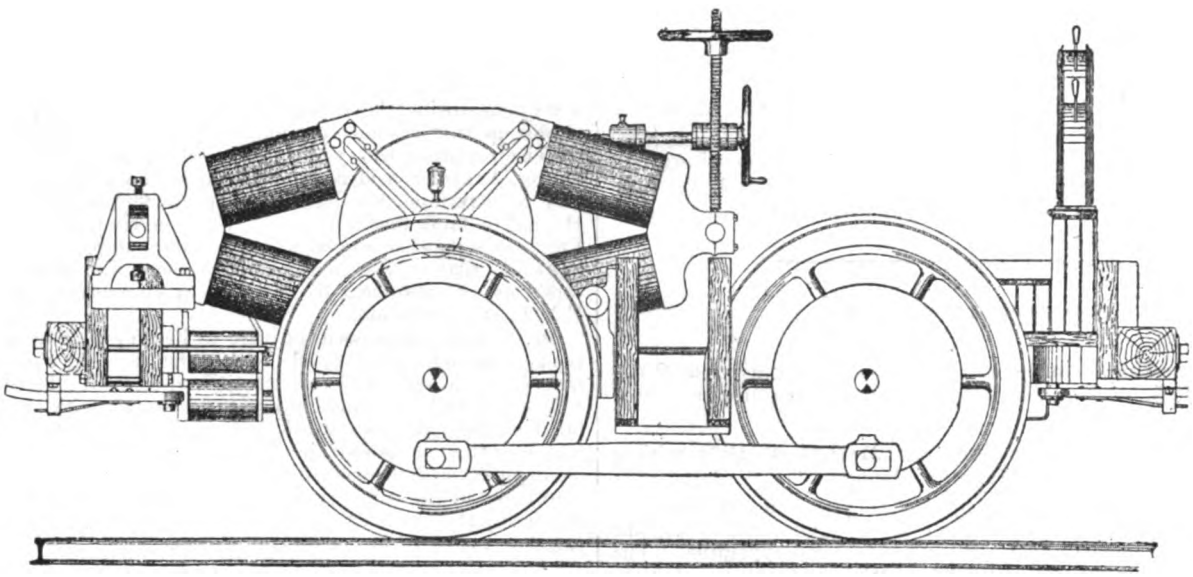
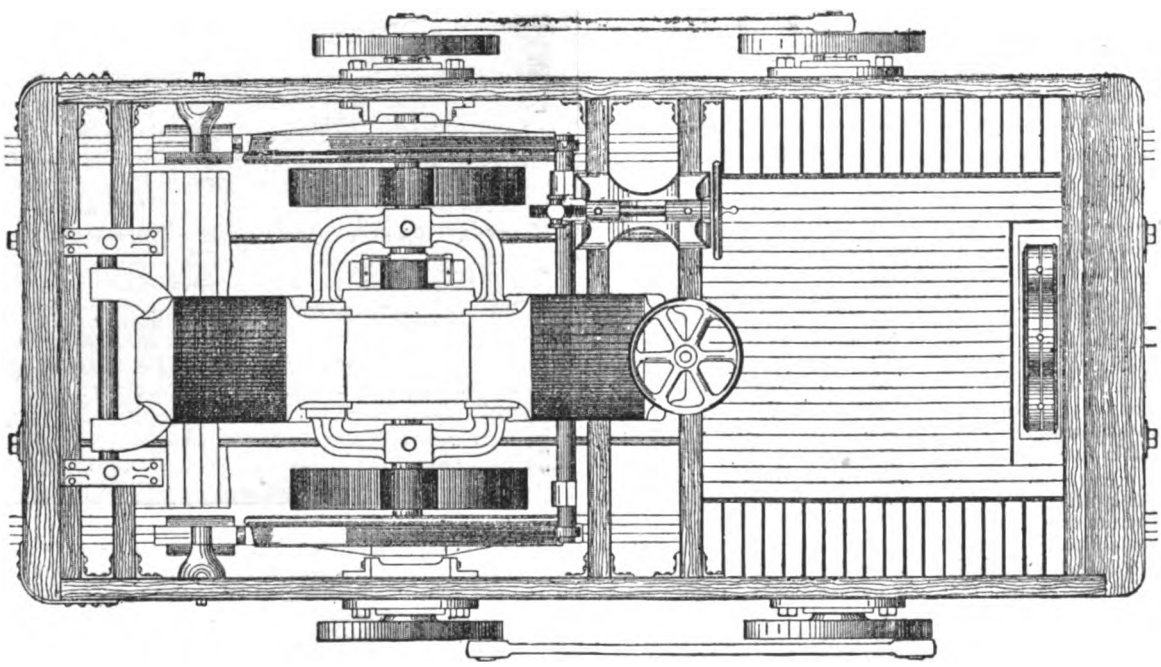
THE "DAFT" ELECTRIC LOCOMOTIVE.



Elevation.



Plan.

We illustrate above two views of the "Daft" 125 horse-power electric locomotive which is now being tried upon the elevated railways of New York. A full description will be found in the letter of our New York correspondent in the present issue.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 1st*, 1888.

The question of operating the elevated railways in this city has cropped up again during the past week. The Daft Company, who some time ago began a series of experiments on the Ninth Avenue-road, have now resumed their work, and appear to have obtained some results which must be characterised as satisfactory. When they began their experiments two or three years ago the motor which they put on, the "Ben. Franklin," was not strong enough for the work given it. It was by no means equal to the steam locomotive in use; and thus, although able to handle one or two cars with facility, it was not able to do anything with the ordinary train of some four or five cars loaded with passengers. The motor, as it now stands on the road, has twice as great a tractive capacity as it had before. It weighs about ten tons, and will develop up to about 125 horse-power. The result is that it can haul four passenger cars, with 176 passengers, or a total weight, with the motor, of 77 tons. With eight cars, aggregating 122 tons, it has ascended the maximum gradient on the road, 98ft. to the mile (1 in 54), at a speed of 7½ miles an hour; with four empty cars, making a train of 66 tons, it has maintained a speed of 25 miles an hour, and with three cars of 52 tons it has kept up a speed of 30 miles an hour. Other changes worthy of mention, besides increasing the power of the motor, have been made.

The old "third rail" method with which the name of Mr. Daft was associated has been abandoned for various reasons, one being that the third rail interfered with the operation of the regular steam locomotives, which still perform the service of the road. For the third rail has been substituted a $\frac{5}{8}$th inch copper rod, sustained by insulating brackets, and secured to the

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guard timbers alongside the track. This conductor is stretched a length of over four miles, from Fourteenth-street to Fiftieth-street, and the whole iron elevated structure is used as a return. The contact is made along the rod by means of brushes. On the motor itself, disc cranks and connecting rods have been added, in order to avail of the adhesion to the rails of four wheels instead of two, and the power is transmitted by friction gear. The new motor used may be described roughly as of the Gramme type, and has two V field-magnets. The power station for the road is situated in Fifteenth-street, about 300 yards from the track, and the current is carried from the generators by insulated wires to the copper rod. A public demonstration of the feasibility of the system was made during the past week, and it was certainly very successful. The night of the trial was one of the dirtiest we have had in New York for a long time. A cold rain storm succeeding a day of heavy snow, accompanied by a strong wind of the blizzard type, made everything as cold, sloppy and greasy as possible. It was an ideal night, however, for showing that the system could operate under unfavourable conditions, and the result was encouraging. A train of cars was taken with a good load of passengers up and down the road, was backed and switched and broken up, and remade, and was pulled and pushed, yet under all conditions the motor responded to the call upon it, and the impression left upon the minds of those who witnessed the test was that electricity was undoubtedly the most desirable motive power for such a road, where, under the present conditions, the smoke, gases, hard coal grit, fine dust and hideous rattle, have combined to make New Yorkers wish that, in spite of their many advantages, such things as elevated roads had never been invented. One result of this successful demonstration on Mr. Daft's part will be, of course, to stimulate the other electrical engineers who have attacked the elevated road problem. But the important point has been gained, I think, that the electrical system as a system is acknowledged by those who have the elevated service in charge to be the best adapted for that purpose. On the night in question several leading officials and stockholders of the road were present, and their appreciation of what they saw was evident to everybody.

We are having lively times just now over the effort made by the United States Illuminating Company to obtain from our New York Supreme Court an injunction restraining the Board of Electrical Control from forcing them to place their wires in the conduits which are being provided in various parts of the city. I have already acquainted you with the status of the matter, and need not, therefore, go into details as to the strength of the opposition made by the United States Company to the work of the Subway Board from first to last. The proceedings at the present time are particularly spicy, from the fact that the company charge that the Subway Board has been guilty of gross favouritism, and that the whole business of the Subway Board is a monopolistic job, the Phœnix Construction Company and the Consolidated Telegraph and Electrical Subway Company, which are carrying on the work under the Board, being practically the Western Union Company, the Metropolitan Telephone Company, the Edison Company, and such individuals as Mr. Maurice B. Flynn. These parties are, it is alleged, operating the subways in their own interests. Going beyond its accusation regarding corruption on the part of the Board, the United States Company alleges that the conduits laid down are suited neither for arc nor for incandescent lighting, and that facilities have not been provided for distribution along the lines of the subway. These statements are supported by a number of affidavits, chief among which is that of Prof. G. W. Plympton, president of the Board of Subway Commissioners of Brooklyn, who believes that no subways have yet been put down that will answer for electric light wires. For its part the Board of Electrical Control, paying little attention to the accusation of jobbery, puts in a number of affidavits showing that the subways are efficient for all classes of electric wires, these affidavits being made by such men as Mr. Barrett, Chief of the Electrical Bureau of Chicago; Mr. J. Elliot Smith, Superintendent of the Fire Alarm Telegraphs of this city; and Mr. Wm. Maver, jun., Electrician of the Western Union Company. Judge Lawrence, who heard the case, however, entered a very strong protest against all this parading of affidavits. The main and only question, it appeared to him, was whether the Board had or had not a legal right to order the United States Company to put its wires underground into the conduits, and he took occasion to have a slap at the experts. "These experts," he said, "always differ. A few years ago I tried a case in which plenty of experts swore that no underground conduits could be constructed in which electrical wires could be operated. Now their ideas have progressed so that all the experts admit that conduits for telegraph and telephone wires are all right. Experts will swear to anything. Dr. Dionysius Lardner demonstrated that a steamship could not cross the Atlantic, and ten days after he published his demonstration the 'Great Western' accomplished the feat. I do not want to have the question of the practical efficiency of the subway thrust upon me in this case." The poor experts, of whom several were present, and who were also represented by strings and bunches galore of affidavits, had the grim satisfaction, however, of hearing the judge go for the lawyers also. The counsel started in very sweetly and glibly showing how well they understood the subject by explaining it to the judge; but before they got very far each time they found it better, after all, to fall back on the specific statements and phraseology of the much derided experts, and thus they aroused the ire of the Court. "Lawyers will persist," he said, "in using ten words where one would do. Why detain the Court with the extra nine words?" Altogether the case has attracted a great deal of attention, the more so because it is seconded by various articles *pro.* and *con.* in the daily papers, each of which feels, of course, that it must have a hand in the fight.

The Telegrapher's Mutual Benefit Association has just held its annual meeting, and it makes a very good report as to the work accomplished. This is an organisation which was started several years ago amongst the operators for life insurance, and it has steadily grown until it has reached a membership in the first division of 3,397, and in the second division of 476, and has a reserve fund of about $73,000. The association has been well managed, and is keenly alive to its responsibilities, not only in the matter of increasing its reserve as much as possible, but as regards extending its area of usefulness. The membership already includes a number of telephone men, and a great number of others who began life in telegraphic work, but have drifted off into other careers, and are to be found in all kinds of positions, chiefly of a prominent and responsible nature. It is now felt that it might not be amiss for the association to include the newer branches of electrical work, and the subject came up for discussion at the meeting. After a period of discussion and agitation, I should not be surprised to see this association, which has done so much good work, placed upon a broader basis, so that it becomes an electrical life assurance association. I do not know whether you have any similar organisations on your side of the water, but on this side, where the telegraphers are in the employ of private corporations, and have no pensions to fall back upon, the association is regarded as doing highly valuable and praiseworthy work.

The coast line of the United States is not a small one, but it begins to look as though very soon it would be girdled by thousands of miles of telephone line, giving a complete system, connected link by link from one end to the other. A telephone service has been put up along the coast of Delaware, and Superintendent Kimball, of the Life Saving Service, now proposes to put one up next March, running along the coast of Long Island, from Coney Island to Montauk Point, a distance of over 100 miles. The work is to be carried out by the Life Saving Corps, and all the preliminary surveying and work have been done. The Long Island line will have some 30 stations, and evidently the work of the Corps will be greatly facilitated. A system has also been inaugurated along the New Jersey coast, which has 23 stations, so that the whole will be operated uniformly and together. The value of the system has already been shown on the New Jersey coast, where formerly dependence was placed on the signal code, which could be used only in fair weather, but now, by means of the telephone, life-saving crews can be summoned at once to any point where they may happen to be needed, and in this way the efficiency and the mobility of the force are greatly increased.

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In connection with what I have said above regarding our elevated system, it is a little bit interesting to note that in Philadelphia, where the cable roads have been put in as a substitute or makeshift for rapid transit, the National Conduit Company is about to make tests of an electric motor on the Traction Company's line. The Philadelphia Traction Company operates a number of miles of cable road, and hence the fact that it is willing to lend its aid for tests with electric motors is rather significant. The president of the company insists that there is no intention to substitute electric power for the cable, but the experience with the cable system in Philadelphia has been such as to lead one to believe that the promoters are not very affectionately devoted to it. The president of the Traction Company is quoted as saying that they regard the cable system as filling all necessary requirements as a motive power with the single exception, that it does not furnish independent power for each car. "This is overcome in the storage system, and becomes the great point of recommendation for that plan." In other words, while the Traction Company proposes to go on with its cable work, it looks to electricity for the final solution of its troubles and difficulties.

NOTES FROM VIENNA.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *Dec.* 3rd.

The Government have now definitely decided on building the trunk line from Vienna to Prague for telephonic purposes. This line is to be run quite separately from the telegraph lines, thus ensuring an absence of many disturbing influences, and it is to be built of 3-millimetre bronze wire. The Government has been much helped by the Telephone Company of Austria doing all that is possible to meet their wishes. In Prague this company is going to very great expense in refitting their exchange with a new switch-board, which will be able to serve single and double lines, and which will enable their subscribers to at once make use of the new trunk line. Other trunk lines are to be carried to Prague, such as a line from Teplitz, another from Richenberg and Brunn, so that soon a large number of trunk lines will join in Prague and connect most of the large manufacturing towns in Bohemia. The exchange in Prague is also growing at a rapid rate, as all those exchanges are doing which belong to the Telephone Company of Austria. The sending of telegraphic messages by telephone to the telegraph office is being made much use of by the company's subscribers. In Prague alone over 28,000 have been sent and received by them since 1st January, 1888. In Trieste the Telephone Company of Austria are also fitting up a new board to greatly improve their service. The calls in Trieste average per subscriber about nine per day, a very high percentage. This new board is being made by the Consolidated Telephone Construction and Maintenance Company, in London, and is a greatly improved board, based on the old board known as the "Consolidated," with many improvements suggested by Mr. R. Howard Krause, the General Manager of the Telephone Company of Austria (Limited). It will take very little room, can be extended to serve 1,200 subscribers, and is a board which comes as near doing the work of a multiple board as such a board can possibly be got to do without being a multiple, and will cost, of course, much less than a multiple would. It is believed that the Consolidated Company intend adopting this type for their switch-boards. The Vienna Company are also rapidly extending their system, and have fitted up their exchange for 2,000, and are extending it to 2,500. They are laying cables for 800 new subscribers, and have all the lines taken up already. On November 26th the first Government exchange was opened in Warnsdorf, in Bohemia, a considerable manufacturing town. This exchange was opened with forty subscribers. Next year the Government hope to open Salsburg, Gablonz, Karlsbad, and some others; but they intend to confine their attentions principally to trunk lines between towns.

On November 10 the Electro-Technical Society of Vienna visited the central station belonging to the Imperial Continental Gas Association in the Schenken Strasse, after having visited the Opera House and the Burg Theatre. The effect on the minds of the visitors, which included many who had hitherto been anything but friendly to the gas company, and who especially disliked the fact that this company ordered most of their machinery in England, was so overwhelming that the society has now addressed the following letter to the gas company:—

"Vienna, November 21, 1888.

"To the Imperial Continental Gas Association, Vienna.

"You have earned the very special thanks of all the members of the society who joined the excursion on November 10 through your very kind invitation, as thereby you enabled them to study an electrical installation which is exemplary, and which is, in its way, equal to the grand arrangements in the two Court theatres. All three installations together are worthy of every praise in the careful thinking out of every, even the smallest, detail of the switches, measuring and controlling apparatus, and are a work which will be a mark in the development of electrical science in Vienna, and in future Vienna will be the centre for all experience regarding accumulators." The letter ends with thanks for the special arrangements made to receive the society, and with thanks to the officials of the company, Mr. Findon, Dr. Teltscher, and the engineers.

The Houses of Parliament in Vienna are to be lit up with the electric light, and Messrs. Siemens and Halske have secured the contract, giving a guarantee for ten years. The well-known summer resort near Vienna, Vöslau, is also to be lit up by electricity, and some of the other numerous country towns round Vienna are sure to follow its example.

The new German "Volk's Theatre" is also to be lit up by the electric light, and Messrs. Ganz and Co., of Buda-Pest, have obtained the contract. The syndicate of the theatre do not pay for the installation, but only a fixed price per lamp, amounting to about 20,000fl. a year, and after a certain number of years the installation is to become their property.

LATER.

Messrs. Ganz and Co., of Budapest, are thinking of opening a central electric lighting station in Vienna, and have applied to the Town Council for permission to lay cables and open the streets. The Committee of the Town Council recommended that this permission be granted on the same terms as to Messrs. Siemens and Halske, but have in this case extended their recommendation that this permission hold good for an eventual second central electric lighting station to be built by Messrs. Ganz and Co.

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

COPENHAGEN, *Dec.* 1, 1888.

The electric light is being installed at present in the Swedish town of Helsingborg, where a central station is being erected in the railway station at the company's expense. The platforms are being lighted by arc lamps, and some of the other localities by incandescent lamps, but the whole of the buildings have not been taken in hand yet. At the harbour arc lamps are also being fixed, and some of the streets in the neighbourhood of the railway station will probably soon have their gas lamps replaced by electric ones.

In Vesteras, Sweden, the gas company has recently erected a central electric station, of which a few particulars may be of interest. It is the first installation in Sweden on the Edison-Hopkinson three-wire system, and it is extended to the different parts of the comparatively small town. The engine house, which is located in the immediate neighbourhood of the gasworks, has a separate boiler room, with one boiler and room enough for another. The steam engine is a horizontal compound one of 55 effective horse-power, and here, too, there is room for extensions. The engine has two fly-wheels, which serve as pulleys, each working a Wenström dynamo, type *h*, each of 350 16-candle incandescent lamps capacity. Outside the engine house the main wires are directed to the different parts of the town, the town hall, the "Norrmalus" part, and the central district. All these main cables are on the three-wire system. The steam engine and the boiler are from Munkeell's Engineering Company at Eskilstuna, and the electric installation, which appears to be thoroughly well done, has been carried out by the Elektriska Aktiebalaget, Stockholm.

In Norway electric light has for the first time been used in diving operations and work under water. The occasion was some repairs on the brig "Vestalinden," and the electric light was supplied from on board the salvage steamer "Pluggen," where an electric installation, intended for use both above and under water, has recently been completed.

In Stockholm and the surrounding country the large Stockholm General Telephone Company and the State Telegraphs have for some time been at loggerheads, and unless a compromise be arrived at, the war is not unlikely to assume important dimensions. The question of the telephone tax gave the first occasion, and the State Telegraphs seem more and more determined to "get at" their opponent. The large State telephone line between Gothenburg and Stockholm is a direct blow against the Stockholm Telephone Company, which was contemplating the erection of a similar line, and which had already completed a telephone line part of the distance (Stockholm - Vesteras), with which the State telephone line is now parallel. The State Telegraphs then bethinking themselves of certain regulations interfering with the right of private individuals to erect poles on State land, the matter was looked into, and about one hundred of the Telephone Company's poles were found to have been placed on State land. Whether the State Telegraphs will compel the Telephone Company

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to remove these poles, and whether the company can remove them without disturbing the whole line, remains to be seen. It is, however, possible, that the State Telegraphs may strike the Telephone Company still nearer home. The State Telegraphs have obtained by Government influence the right from the town of Stockholm, "before everybody else," to attach to the houses the lower supports for telephone wires. That it has the same right as far as the buildings of the State are concerned goes without saying. It remains doubtful how far the State Telegraphs will make use of this right; but so much is certain, that the State Telegraphs through this right can, if they choose, erect their own telephone system within the town, and that they in that case have preference before all others, whether already existing or future companies. This latter alternative is, however, one must presume, not very likely to become a reality.

CORRESPONDENCE.

THE MAGNETIC EFFECT OF CONVECTION AND DISPLACEMENT CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of November 16th a suggestion from S. P. Thompson that it would be advisable for some one to repeat Prof. Rowland's convection experiments. Prof. Rowland himself desires to get more accurate measurements than were possible with his Berlin apparatus, and to that end has designed a new form for the experiment; this I have been working on for some time past.

In the new apparatus there are two gilded ebonite discs surrounded by guard rings, and revolving on horizontal axes; the lower element of an astatic system hangs midway between the discs, in the line of their centres.

The discs are run at about 100 to 130 revolutions per second, about double that attained in the old experiment; this higher speed, with higher electrification, will make the determination a more accurate one.

Although no measurements have yet been made, the quantitative effect is easily obtained. Deflections of about half a degree of arc are got by reversal of comparatively low electrification.

I may also add that experiments on the magnetic effect of displacement currents have been made at this laboratory. The deflections, as calculated from the dimensions of the apparatus, &c., were great enough to be observed with certainty; but the disturbing causes were so numerous and so great that the work has been given up for the present.—Yours, &c.,

CARY S. HUTCHINSON.

Physical Laboratory, Johns Hopkins University,
Baltimore, Md., December 3, 1888.

ELMORE'S ELECTRO-BURNISHING PROCESS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent, M. Gaston Roux, I herewith supply an abstract of the results of a series of tests which have been made on the above wire, and which will, I hope, give the desired information:—

ABSTRACT OF RESULTS.

All at 0° Centigrade.

Size of wire.			Resistnce of 1 metre. Weighing 1 gramme.		Ratio of conductivity of annealed and hard wire.	Percentage conductivity relative to hard standard copper.	Density.	Mean elongation under breaking strain.
B.W.G.	Diameter in inches, approx.	Condition.	Hard.	Anneal'd				
			B.A. ohms.	B.A. ohms		Per cent		Pr ct.
12	0·113	hard	0·14337	—	—	102·46	8·343	2
		annealed	—	0·14072	101·89	—	8·939	—
14	0·0825	hard	0·14330	—	—	102·51	—	1½
		annealed	—	—	—	—	—	—
17	0·057	hard	0·14359	—	—	102·31	8·938	¾
		annealed	—	0·14069	102·06	—	—	—
18	0·049	hard	0·14366	—	102·21	102·26	—	¾
		hard	0·14357					
		annealed	—	0·14056	—	—	—	—
21	0·031	annealed	—	0·14061	—	—	—	—
General mean.....			0·14349	0·14065	102·01	102·38	—	—
Say.....			0·1435	0·1406	102·0	102·4	—	—

From the general mean above has been calculated the resistance of a wire in different units of length, weight and diameter, as under; all values at 0° C.:—

Resistance of a Wire in B.A. Ohms.

—	1 metre weighing 1 gramme	1 foot weighing 1 grain.	1 statute mile weighing 1 lb. (avoird.)	1 nautical mile (2029 yards) weighing 1 lb. (avoird.)	1 metre long and 1 millimetre in diameter.	1 foot long and $\frac{1}{1000}$ inch in diameter.	1 statute mile long and ·065" in diam. = No. 16 B.W.G.
Hard.	0·1435	0·2057	819·4	1089·0	0·02043	9·652	12·06
Annealed.	0·1406	0·2016	802·8	1067·0	0·02003	9·461	11·825

It will be seen from the above that the resistance at 0° C. of the hard drawn wire 1 metre long and 1 millimetre diameter is ·02043 B.A. ohms, and when annealed is ·02003 B.A. ohms. The corresponding values for so-called "pure," or, say, standard copper are ·02104 hard and ·02057 annealed (B.A. Reports). Hence the conductivity with respect to *volume* is 102·98 per cent. hard and 102·7 per cent. annealed.

The *specific resistance* of, say, the annealed wire in B.A. microhms is obtained thus—

$$\frac{\cdot02003 \times 10^6 \times \cdot7854}{10^4} = 1\cdot573 \text{ B.A. microhms.}$$

Otherwise thus—

Since 8·939 is the density of the metal, this number expresses the weight of 1 cubic centimetre; hence a bar 1 metre long and 1 square centimetre in section would weigh 893·9 grammes, and would have a resistance $\frac{1}{893\cdot9}$ of a wire the same length and weighing 1 gramme $= \frac{\cdot1406}{893\cdot9}$; hence a length of 1 centimetre of this bar would have a resistance of 1·573 B.A. microhms, as before.

I would also refer your correspondent to an article which appeared in your contemporary *Engineering* for November 23rd, 1888, pp. 509 and 510.—Yours, &c.,

December 11th, 1888. C. J. S.

ELECTRIC LIGHTING OF SCHOOLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow an amateur, who began his experiments nearly half a century ago, and who has made the subject his "hobby" ever since, constructing his own apparatus, and assisting others, to write a few words on the above subject as carried out in the schools of Holy Trinity District, Eastbourne? I have always been deeply interested in electric lighting since, close on forty years ago, I helped a well-known Cheltenham amateur, now passed away, in producing an arc with 120 Smee cells, at the Shire Hall, Gloucester.

It is well known to many of your readers that our town of Eastbourne is somewhat in the van with regard to electric lighting, and perhaps to them and others it will be interesting to hear a few particulars of our company's doings since the new departure of having a central station near the railway terminus, under the able management of Mr. H. T. Harris and an excellent staff, with efficient workmen to carry out the details.

At this station any evening, and during winter from 6 to 8 a.m., is to be seen in full work an engine of 200 horse-power, making 92 revolutions per minute, driving one large alternating dynamo making 550 revolutions per minute.

From this centre two main cables distribute the current thus produced throughout the town—the furthest point reached represents nearly three miles of underground wires enclosed in iron pipes. This most distant house is a large ladies' school.

This alternating current of 2,000 volts is carried into any house or group of houses by a main brought into celler or outhouse, where is fixed the converter or transformer—a most important instrument designed to transform the 2,000 into a 100 volt current for use within. To those who do not know this instrument I may just mention that it consists of a large core of very soft laminated iron, surrounded by a primary coil of *fine* wire, the secondary coil being made of *stout* wire, the reverse of ordinary coils. The iron core becomes bathed or saturated with magnetism, and induces the comparatively low-tension current for lighting the incandescent lamps,

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and can be arranged for any number. The next very important matter is that of *measuring* the current used. For this purpose a "Lowrie-Hall-Kolle" meter is used, the principle of which being the deposition of metallic copper (as in an ordinary cell) by a differential current of 4 volts produced by the introduction into the circuit of an accumulator. The deposit is comparatively slight, but when accurately weighed it shows exactly what has passed into the building. A matter of great importance to the public is that if this meter acts imperfectly the record is against the company, as *over deposit* cannot take place. The wires carry the current from the meter direct to the lamps through earthenware switches, safety fuses being used everywhere.

Our school premises comprise one large room 100ft. long by 24ft. wide, subdivided by movable partitions into four nearly square rooms, and another smaller room, 52ft. by 22ft., not divided, besides four good-sized class rooms. Each square room in the large building is lit by four 16-candle lamps, suspended from the beams near the corners, and one 32 in the centre. The smaller one has eight lamps of 16 candle-power hanging from beams at regular distances, while each class room has two. This gives a delicious mellow light; but if this were the only advantage our management would not have abolished gas in favour of electric lighting. *The* great advantage of the latter is, the air does not get vitiated by its use, vitiated not only by the consumption of oxygen and formation of carbonic acid, but by the introduction into the atmosphere of a very considerable variety and amount of deleterious chemical agents, which do much damage to health and property.

Take our schools as an example. We have over 600 children in attendance. At this time of the year towards 3:30 we must light up for an hour: the air is already vitiated, and brains begin to be fagged as a consequence. All at once 70 gas jets at least are alight, and each at a low computation consumes as much oxygen as six persons; the equivalent of *420 more* people is crowded in, whose breath—well, we will not say what they breathe out, chemists will tell us that.

With the new light all this is changed, and the last hour goes, not so easily as the first—that is impossible—but I hardly know how fitly to describe it.

I trust to see our church lighted with it ere long—one Eastbourne church is already—and I feel sure that very soon this will become *the light*, while our old friend gas, to whom we are grateful for past favours, will more and more take the place of coal for heating and cooking purposes.—Yours, &c.,

THOS. RYDER.

Holy Trinity Schools, Eastbourne, December 5, 1888.

THE GEYER-BRISTOL AMMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The ammeter described in your last issue under the above name is no doubt a very useful instrument for small currents, but I am afraid an upward limit would soon be reached. Some two years ago I tried some experiments with a similar idea, the compound strip being in my case composed of brass and iron coiled up into a flat spiral. To eliminate error due to air temperature two of these spirals were used; to one was attached the pointer and to the other the dial. So long as the two were at the same temperature there was no relative movement of the pointer on the scale. That is to say, both the pointer and dial moved together, and so kept in the same position with respect to one another. But on passing the current through the spiral carrying the pointer a deflection was obtained. This instrument was fairly satisfactory for small currents, though the time required for the indications to assume their correct and final value was somewhat large, varying with the current. On using the instrument for large currents, in addition to the increased time required to attain the maximum deflection for any current, another difficulty was observed in the shape of the leads growing proportionally hot for some considerable distance to and from the instrument. This difficulty will, I think, be experienced with all ammeters depending for their action on the heating of a part of the *main* circuit. To overcome this some experiments were next tried by me with an arrangement having the heated portion as a *shunt* to part of the main. Thus a length of 2ft. of the main was bent into a U-shape and shunted by about 1ft. of wire of small section relatively to the section of the main. The sag due to heating of this fine wire was observed directly on a small scale. This made a somewhat bulky instrument with very small scale, but was free from the other objections.—Yours, &c.,

SAM. JOYCE, JUN.

113, Richmond-road, Dalston, E., December 8th, 1888.

PROVISIONAL PROGRAMME OF THE INTERNATIONAL ELECTRICAL CONGRESS OF 1889.

The following is the programme which the Executive Committee propose to lay before the forthcoming International Congress of Electricians at Paris:—

FIRST SECTION.—MEASUREMENTS.

Units of measurement. Recent determinations of the unit of resistance. The ratio of the electro-magnetic to the electrostatic units. New names for practical units. Measuring instruments. Resistances. Alternating and continuous currents. Electromotive forces. Capacities. Coefficients of induction. Practical standards of current and E.M.F. The magnetic and electrical properties of metals.

SECOND SECTION.—DYNAMO MACHINES; MOTORS; ELECTRICAL DISTRIBUTION; TRANSFORMERS.

Recent progress in the theory and construction of dynamo machines. Different methods of calculating the data of a machine. Electro-magnetic armatures with iron cores. Electro-dynamic armatures without iron. Machines for lighting, transmission of power, generators and receivers, electrolysis. Output. Machines for distribution. Different methods of automatic regulation. Mechanical and electrical methods. Transmission of power. Mains. Central stations. Possibility of constructing very large machines. The employment of many small machines, or of a few large machines. The advantages of coupling machines in parallel or of running independently. Transformers. Alternating-current and continuous-current transformers; the two systems compared. Alternating-current transformers; their theory, improvement, efficiency. Different methods of distribution. Automatic regulation. Alternating-current dynamos and motors, compared with continuous-current machines. Discussion with regard to the machines and other apparatus used in continuous-current distribution and in alternating-current distribution by means of transformers.

THIRD SECTION.—ELECTRO-CHEMISTRY.

1. *Batteries and Accumulators.*—Practical value of the chief types employed; E.M.F.; output, durability, &c.

2. *Electrolysis.*—The E.M.Fs. necessary to decompose the ordinary iron compounds. The conditions necessary for a good deposit of the ordinary metals: copper, silver, gold, nickel, platinum, &c. Current densities, composition of baths, temperatures, &c., required for the various kinds of deposits.

3. *Electrometallurgy.*—Principal methods of separating and refining metals. The production of metals and alloys by electric furnaces.

FOURTH SECTION.—LIGHTING.

Respective values of arc and incandescent lighting. Advantages and disadvantages of high candle-power incandescent lamps. Methods to employ when running arc lamps in series or parallel, without rheostats between the lamps and the machines. Best methods of manufacturing incandescent lamps with a view to increasing their life and efficiency. Best methods of erecting and working central lighting stations.

FIFTH SECTION.—TELEGRAPHY AND TELEPHONY.

1. *Telegraphy.*—The employment of dynamo-electric machines. Underground wires, their employment, laying, and life. Telegraph lightning guards. Fast-speed transmitters: their working and employment. Multiplex apparatus.

2. *Telephony.*—Running wires; steel, bronze, hard-drawn copper, compound wires. Insulators. Joints. Posts and stays. The employment of overhead and underground wires. Dampers. Methods employed to overcome mutual induction. Metallic circuits. Simple or multiple switch-boards. The number of subscribers served by one operator; the number of connections which can be made by one operator in an hour; the time necessary to make a connection. Interior economy of exchanges. Rules for subscribers. The repair and maintenance of subscribers' instruments. Microphones. Batteries. Running several instruments on the same line. Statistics. Legislation. Development of the system. Tariffs. Automatic Posts. Interurban telephony.

3. *Various Applications.*—Electricity applied to railways, to civil engineering, to military and naval purposes, to clocks, to chronography.

SIXTH SECTION.—ELECTRO-PHYSIOLOGY.

Comparison of the effects obtained when using various kinds of electro-medical apparatus. The necessity for defining the currents employed in medicine and connecting them with the usual electrical units. The best methods of determining the exact nature of electric phenomena in animals. The effects of alternating and continuous currents on living beings. Electrolysis of the tissues. Dangers of electrical installations. The conductivity of organic bodies, especially that of the human body.

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PARLIAMENTARY NOTICES UNDER THE ELECTRIC LIGHTING ACTS.

In addition to the Provisional Orders for which, as stated in our last issue, application will be made to the Board of Trade by the 21st inst., two others have to be noticed, which will be applied for by the Electrical Power Storage Company (Limited) and the House-to-House Electric Light Supply Company (Limited).

The Electrical Power Storage Company will ask for an Order (besides that which we have noticed relating to their proposed lighting in the parish of St. Martin's-in-the-Fields and the Strand District) authorising them to produce, store, and supply electricity in the Parish of Paddington. Among the streets, &c., in which it is more particularly proposed to place electric lines and works, are London-street, Devonport-street, Sussex-place, South Wharf-road, North Wharf-road, Harrow-road, Irongate Wharf-road, Praed-street, Cambridge-place, Market-street, Norfolk-square, Star-street, Sale-street, Edgware-road, Watling-street, Gloucester-square, Radnor-place, Somer's-place, Southwick-place, Grand Junction-road, Hyde Park-square, Albion-place, Chester-place, Hyde Park-gardens, Clarendon-place, Hyde Park-street, Albion-street, Upper Porchester-street, Cambridge-square, Southwick-crescent, Oxford-square, Norfolk-crescent, Burwood-place, Cambridge-street, Portsea-place, Upper Berkeley-street West, Berkeley-place, Connaught-square, Upper Seymour-street West, Connaught-place, Stanhope-place, Uxbridge-road, Gloucester-gardens, Porchester-mews, James-street West, Cleveland-gardens, Porchester-terrace, Leinster-gardens, Cleveland-square, Craven-hill, Lancaster-gate, Upper Hyde Park-gardens, Devonshire-terrace, Craven-terrace, Westbourne-terrace, James-street, Bishop's-road, Eastbourne-terrace, Craven-road, Charles-street, Spring-street, Westbourne-crescent, Sussex-square, Westbourne-street, Bishop's-road Bridge, Bishop's-road Station, Paddington Station, Praed-street Station, Talbot-square, Conduit-street, Delamere-street, Westbourne-terrace-road, Westbourne-terrace, Queen's-gardens, Gloucester-place, Gloucester-terrace, Lancaster street, and Stanhope-street.

The House-to-House Electric Light Supply Company (in addition to their intended application—noticed in our last issue—respecting the lighting of the parish of St. Mary Abbotts, Kensington) will ask for an Order empowering them to produce, store, and sell electricity in the Strand district. They notify that "the houses on both sides of every road or street in the area of supply are included within the area of supply."

LEGAL INTELLIGENCE.

Edison and Swan Electric Light Company v. Holland and Others.

THE CASE ON APPEAL.

The hearing of this case was resumed in the Court of Appeal, before the Lords Justices Cotton, Lindley and Bowen, on Thursday, December 6th, at 2 p.m.

Sir Richard Webster (the Attorney-General), Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Bremner appeared for the appellants; and Sir Horace Davey, Q.C., Mr. Finlay, Q.C., and Mr. J. C. Graham for the respondents.

Mr. MOULTON concluded his argument on behalf of the appellants. Thin weak carbon was enough in itself for the purpose of this patent without strengthening it with anything else. A mere filament would stand a terrific strain owing to high temperature.

LORD JUSTICE COTTON: Mr. Justice Kay relied on the fact that all the lamps that were sold were made under the improved methods.

Mr. MOULTON: A new type of lamp was not produced, and it is not necessary that the lamp should be a commercial success; and I contend that it is not a good legal objection to say that a patent is useless because another method is a better one.

LORD JUSTICE LINDLEY: That was settled in the musical instruments case.

Mr. MOULTON: And the same argument will apply in this case.

This concluded the case for the appellants, and that for the respondents was then opened.

Mr. FINLAY: I wish to show that the principle was not new and the processes were worthless, and if I make out either of these arguments, the patent fails. It has been suggested that we have infringed their process by forming a filament before carbonisation. Now we want to show that the design was not new. In the case of Woodhouse and Rawson there were four points of difference as compared with this case. The fourth point, which was of the most importance, was that in the former case the utility of the patent was admitted—that was not disputed. What we say in the present case is that we have not infringed the process claimed in this patent. The only attack made upon us before Mr. Justice Kay, and which the evidence will support, is the allegation that we have infringed the principle which is claimed by Mr. Edison in the second claim of this patent.

Mr. BREMNER: I do not admit that.

Mr. FINLAY: The claim was for the infringement of the principle, not for the infringement of the process.

Mr. BREMNER: The shaping before the carbonisation is admitted.

Mr. FINLAY: I apprehend that if the modes of carrying out the principle as described, or any of them, are insufficient, the patent will be bad. If a patentee took out a patent for a new principle and described six possible ways of carrying it out, and one of those modes was bad, the patent would be bad altogether. Now, we say in the first place that there is nothing new in the principle, and that in three points the process described has been proved to be insufficient. The secret history of this matter no doubt is that this patent, which was never heard of at the time it was brought out, was raked up for the purpose of making a monopoly in these lamps.

Mr. ASTON: It was carried on.

Mr. FINLAY: It has been admitted that no lamp was ever made under this patent except for purposes of litigation.

Mr. ASTON: No.

Mr. FINLAY: My friend grunts (a laugh), but that is the case. I do not think my friend can point to any evidence as to a single lamp having been made under this specification except for purposes of litigation. I challenge my friend to point out a single case.

Mr. ASTON: That is so with reference to cotton thread; but as to bamboo filament, there was abundant evidence that they were made so far back as 1881.

LORD JUSTICE COTTON: That was my impression.

Mr. FINLAY: These bamboo lamps were made under patent—

Mr. ASTON: I made a mistake. I should have said March, 1880, and not 1881.

Mr. FINLAY: I think my friend Mr. Aston is really under a misapprehension about this. Mr. Graham's recollection agrees with mine upon the point. Moreover, the witnesses who tried to make filaments out of tar putty and failed had not put to them in cross-examination the point on which their failure depends. It is clear, therefore, that those who were conducting the case then for the plaintiff company had not the least idea what the real essential point in this process was. Now as to the process of carbonisation. Of course it was known before the date of Edison's patent, but not the carbonisation of such a delicate structure as filament, but only for the purpose of making gunpowder, &c. The attack made is that the experiments were not fair experiments because the crucible used was porous; but the crucible used was an ordinary earthenware crucible, and I contend that there is no ground for attack on the witnesses on this point. What we say is that we have established that the description is insufficient and the process useless; and I apprehend it is enough for us to show on any one point that the description of a method given for carrying out the principle of a scheme is insufficient, and that if we do that the whole thing breaks down. I will now call attention to the evidence adduced in the case in the Court below, and I will deal with the question of fact, and not so much with the question of law.

LORD JUSTICE COTTON: You are entitled to argue, but I shall follow the view of the Court below.

Mr. FINLAY: There is a good deal of evidence which has not been brought before that Court at all. A question of novelty is a question of fact.

LORD JUSTICE COTTON: If you can give us evidence on the question of novelty you may proceed, but I thought you wished us to change our view as to the sufficiency of this specification.

Mr. FINLAY: I shall submit that there was a great deal of evidence not before the Court at all on this point—that there is really no novelty whatever in high resistance with regard to this particular lamp. We say there is no novelty. If the point of the process is that the carbon filament was formed before carbonisation that was not new, because it had been used in lamps made by Mr. Swan before the date of this patent. After reviewing the evidence of Sir Frederick Bramwell, Mr. Finlay added: We shall submit that this patent really had no appreciable effect whatever on electric light, although it has been claimed for it as having introduced the only commercially successful electric light. Prof. Stokes's report also shows that electric light, made even with the aid of all the information obtained up to the present day, could not, if carried out according to the specification of Mr. Edison, be commercially successful.

LORD JUSTICE BOWEN: Do you deny its utility?

Mr. FINLAY: I say that if there were no other electric light lamps at all these lamps would not be a success.

Mr. ASTON: Why not?

Mr. FINLAY: On account of their short duration. Then, again, the only lamps made by Mr. Gimingham were made out of lampblack and putty. He did not try any lamps made under any of the processes described in this specifiation; and that brings me to the end of the case as produced on behalf of the appellants. Amongst the grievances unfolded by the Attorney-General was one to the effect that they had not been allowed to bring the whole of their case before Mr. Justice Kay. Now, after the advantages enjoyed by Mr. Aston I cannot understand this grievance of his learned leader. I propose to call attention to certain portions of the evidence given on behalf of the defendants in the action. I think it necessary to read enough of the evidence given by our witnesses to show that they really did try to make conductors by processes mentioned in Mr. Edison's specification. I will also direct your lordships' attention to the cross-examination of those witnesses, and ask you to make the necessary inference in favour of the respondents. Undoubtedly a great amount of detail will be saved by reading the report of Prof. Stokes.

At this stage the Court adjourned.

The case was resumed on Friday morning.

Mr. FINLAY: This outburst of activity in incandescent light did not take place until considerably after the patent now in question, as I will show by the evidence.

LORD JUSTICE COTTON: I thought you were going to raise the question of novelty.

Mr. FINLAY: Certainly.

LORD JUSTICE COTTON: Will you not take that first?

Mr. FINLAY: I thought I would establish the point I have mentioned. What we shall show is this—that the first exhibition of Edison lamps in Europe was in Paris in 1881, and the first exhibition in England was in the autumn of 1882 at the Crystal Palace. With these exceptions

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the only evidence as to any Edison lamps having been seen by witnesses relates to six lamps referred to by witnesses which were not made under this patent, but under the patent of November, 1879. I mention that as an important point, which can be supported by evidence.

LORD JUSTICE BOWEN: We should like to have a list of the experiments which have been conducted, and which have proved to be failures.

Mr. FINLAY: I will have the list made out, my lord. Now, we say that the process as conducted by us at our works would not be an infringement of any of the processes in Mr. Edison's patent.

Mr. ASTON: We contend that you have infringed.

Mr. FINLAY: We work up the tar putty for such a length of time and with so much force that it makes the necessary filament and is very different from what it was before.

After reading a body of evidence on the question of manufacture, Mr. FINLAY added: The cross-examination by Mr. Aston and other counsel for the appellants does not contain a hint as to the necessity of going on with the working up of the tar putty for the length of time, and with the expenditure of force which has been found necessary and which makes all the difference between failure and success. At that time the plaintiff company did not know how to make up filaments from this tar putty, and yet I suppose their counsel was put in possession of all the information they had upon that point.

Mr. ASTON: We brought the filament into court. We actually did it, and knew how to prepare it.

Mr. FINLAY: Then you kept it to yourself, because there was not a hint about it in court.

Mr. ASTON: There was not a point made of it on the other side.

Mr. FINLAY: Oh! Now the secret consists of going on for a hour and a-half after the putty has become homogeneous, so that with great force filaments can be formed. I think my friend Mr. Aston, in saying he knew that at the time, was imagining (a laugh). He would have let it out had he known it (laughter). Then as to the cross-examination of the witnesses as to the directions in the specifications being sufficient to make a practically useful lamp, it is idle to suggest that while the directions are not sufficient, they may be supplemented by something else in another patent or by scientific knowledge now possessed with regard to the filament.

LORD JUSTICE LINDLEY: If you confined yourself too rigidly to the specification, I suppose you could make nothing out of it.

Mr. FINLAY: Of course knowledge is required.

LORD JUSTICE LINDLEY: Of course with a certain amount of skill and a certain amount of desire to succeed.

Mr. FINLAY: If I was told to chew I should do it, and do it thoroughly (laughter). Take, for instance, the case of the tar putty. How could it have been known that it was necessary to go on after it was tar putty. The secret of failure is now known, but it is not a thing that even a scientific man could possibly know. We produced five or six scientific witnesses who all tried to deal with this tar putty and failed, and it was never suggested until Prof. Stokes' experiments what the secret of success was. We cast about in all directions, but it was not revealed till after Prof. Stokes' report, and we then found that the thick putty could be made into the necessary consistency for filaments, after the exercise of great force, at the end of a certain time.

LORD JUSTICE LINDLEY: Have samples of the failures in working up the thick putty been produced?

LORD JUSTICE BOWEN: I am not aware that such samples have been produced.

Mr. ASTON: My friend Mr. Finlay's statement as to the change in the character of the tar putty is not borne out.

Mr. FINLAY: I contend that my friend, Mr. Aston, did not cross-examine about the character of the putty or of the nature of the crucible used. As a matter of fact, too, the lamp F J B 1 never broke down. (Mr. Aston dissented). My friend shrugs his shoulders (a laugh). The electric light was turned off.

LORD JUSTICE BOWEN: But it smoked.

Mr. FINLAY: If it did it was very slightly.

LORD JUSTICE LINDLEY: There was smoke on the glass.

Further reviewing the evidence Mr. FINLAY added: Mr. Justice Kay referred to the fact that, in his judgment, at that time there was no industry for making filaments; there was no class of workmen for the purpose.

LORD JUSTICE BOWEN: Would an ordinary chemist have understood the process?

Mr. FINLAY: I do not think an ordinary chemist would do it. I submit it is conclusive on this point. How could a man have known that in working out this specification, after the application of great force and a certain expenditure of time, the necessary filament could be obtained from the thick putty? The appellants themselves did not know the secret until after a series of laborious experiments performed for the purpose of winning this case.

Alluding to two experiments referred to in the evidence as "Tar putty A" and "Tar putty B," Mr. FINLAY said: The difference between the two was the addition of a little lampblack before it came to the required consistency.

Mr. ASTON: No reference was made to the last addition of lampblack before.

Mr. FINLAY: Then on the question of the admixture of oxide of zinc with the tar putty, I do not know what is the suggestion of my friends on the other side as to the flaw in these experiments. They do not use, as Mr. Justice Kay said, the proportion of oxide of zinc required.

LORD JUSTICE COTTON: If we are to go into an infinite number of issues we shall never get through it.

LORD JUSTICE BOWEN: I did not know we were going into this question of oxide of zinc.

Mr. FINLAY: Then as to the question of non-conducting, non-carbonisable substance, it cannot be said that we have coated the conductor with one-third of its size, because we have merely "dusted" it with asbestos.

LORD JUSTICE LINDLEY: What you say is that "dusting" is not "coating?"

Mr. FINLAY: That is so.

LORD JUSTICE COTTON: If we go on like this we shall not finish till some time after Christmas (laughter.)

Mr. FINLAY (after reading some further evidence): We approve of Mr. Sellon's experiments as well as Dr. Tidy's, which had been made quite apart from Mr. Crookes's.

The ATTORNEY-GENERAL: The question is whether the infringing lamp was made in accordance with the latest specification. I hope your lordships will watch the evidence on this point.

Sir HORACE DAVEY: We intend to rely upon that.

Mr. FINLAY: We have challenged over and over again the appellants to say that lamps were made after the pattern of 1879, except for trials, and they failed to do so. We say that no single commercial lamp was made under that pattern, that there was insufficiency and want of utility in those which were made.

At this stage it was agreed that Sir HORACE DAVEY should address the Court on behalf of the respondents. He said: The Attorney-General, in the course of his speech, referred more than once to the fact that I was leading counsel for Woodhouse and Rawson.

LORD JUSTICE COTTON: It will not make the slightest impression upon us.

Sir HORACE DAVEY: I must now ask your lordships not to be influenced by the evidence in the previous hearing, but to give full consideration to that which we now put before you and the new points we have raised. Now, the second claim is framed in language which includes the combination of the parts, including filaments made not only in the manner prescribed in the specification, but in any conceivable manner in which filaments could be made. The question which comes before you, in a different form and under different materials, is what is a filament within the meaning of Edison's specification, and how does it affect the former judgment?

The case was here adjourned.

SATURDAY, DECEMBER 8.

Sir HORACE DAVEY continued his addressed on Saturday morning. He said: We have brought before your lordships a body of evidence—cogent evidence—as to the wholly insufficient direction contained in the specifications to enable any person to make a successful lamp. We have established this remarkable fact, that no single lamp is known to have been made by Mr. Edison, or anybody else, in accordance with the specifications, without the addition of the directions. I have looked through the evidence again, and although my friends on the other side were challenged to produce a lamp so made no evidence as to such a lamp having been made was produced. A lamp was certainly handed up to the Court, and we were told that it was made in accordance with Mr. Edison's specifications; but that is now known to contain other elements, and to have been made not exclusively according to the directions of the patent of November, 1879, but according to those of subsequent patents. If the second claim has the wide signification which the witnesses give to it, it fills the whole field of incandescent lamps. In the present case the filament is made in a totally different manner from that described in the specification, and we say that no lamp is known to have been made exclusively from the directions contained in the specification of 1879. On this point the case comes before you in a totally different aspect. The second claim covers all incandescent lamps which contained a filament, however made and of whatever resistance. Now I reserve to myself to question the correctness of this claim; I do not abandon it on the part of my clients. In order to protect a principle you must first have discovered the principle, or the principle must be new; secondly, the modes of carrying it into effect must be sufficiently described, and produce a certain practical result. We contend on these points that the principle is not new, as shown by the evidence of Mr. Swan and other witnesses; and that although Mr. Edison supposed he was the discoverer of the principle, the modes described in the specification are insufficiently given, and do not produce practical or successful results. We dispute Mr. Edison's claim to have discovered the idea, and to have a monopoly of all lamps which come within the idea; and we say that Mr. Edison's patent of November, 1879, was nothing more than a statement of an idea with a few crude and imperfect suggestions for carrying that idea into effect. That is our view, and we hope to make it good. Now a good deal of comment has been made on the words "commercial value"; but they were used by Sir Frederick Bramwell, and when he was cross-examined with regard to them he took refuge in generalities. With regard to the word filament, it is evident that its real meaning was not known at the time of this patent. If you look at the specification you will find that it includes such things as "wires" and "strips of paper," but there is no such definition or delimitation of "filament" as would satisfy the undoubted requirements of the patent law by particularly showing the nature of the invention.

LORD JUSTICE BOWEN: I do not know how far we are bound by the previous decision.

Sir HORACE DAVEY: Supposing that case was inefficiently argued on that occasion?

LORD JUSTICE BOWEN: Is this a question of law or of fact?

Sir HORACE DAVEY: I should think it is a question of fact.

LORD JUSTICE COTTON: A material fact has been brought out—namely, as to the formation of the "pencil," as it is called, before carbonisation. But I do not at present see that anything has been brought forward to show what "filament" really is.

LORD JUSTICE LINDLEY: I think this question of whether or not it has been sufficiently described is the most important in the whole case.

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Sir HORACE DAVEY: I admit that so far as Mr. Swan was concerned the principle was known to him; but what was wanted was, knowledge of the way in which to carry it into effect by perfecting the details. I will now point out that in the case given in Webster of Turner and Winter it is laid down that if a patent is insufficiently described, or if there is ambiguity in the specification, the patent is void. The question in this case is, whether the nature of the invention is sufficiently described, so as to protect it—in other words, What was the meaning of the word filament, as used in the claim? Dr. Hopkinson has stated that the exact meaning cannot be given; but we say that it must be given for the purpose of this case. The suggestion made by Mr. Edison is that you should have a carbon conductor; that it should be as homogeneous as possible; and that you should get your resistance by increasing the length of your filament. I refer to that as showing that small sectional area was by no means a necessary element, and I submit there is not sufficient definition of the sense or meaning of the word filament in the second claim, and that the lamp F J B 1 was in anticipation of that claim. The fact is, it was not known that it was necessary to go on working up the tar putty until it acquired a particular consistency more resembling gutta-percha.

Mr. MOULTON: That is nonsense; there is not a particle of evidence about that.

Sir HORACE DAVEY: I am not going beyond Prof. Stokes's report. It was not till after that report that the witnesses knew how to make the filament, in regard to which Mr. Edison's specifications in his patent were insufficient. The same thing may be said with regard to the crucible, and the coating that was required for the conductor. The directions were, in fact, crude and insufficient, in exactly those points which Mr. Edison described as recent discoveries in his new patent. These are the points upon which we rely, and upon which we hope your lordships will decide in our favour.

The Court was then further adjourned.

(The remainder of this report will appear in our next issue.)

THURSDAY EVENING.

The ATTORNEY-GENERAL concluded his address this afternoon, having described the experiments carried out for Mr. Justice Kay's information as not having been made in accordance with the instructions contained in the specification as far as the tar putty was concerned, especially as to the kneading process. If their lordships' judgment was in his favour, he should ask to be heard as to the terms of the order.

Their lordships reserved their judgment, arrangements having been made for them to have access to the exhibits.

King, Brown and Co. v. The Anglo-American Brush E'ectric Light Corporation.

WEDNESDAY, DEC. 5.

The defenders' case was resumed to-day before Lord Trayner. His lordship intimated that he would give Thursday and Friday for the proof, but that it must finish on Friday. The Dean of Faculty indicated that it would finish on Friday.

The cross-examination of Prof. S. P. Thompson was resumed by Mr. Graham Murray. *Q.* In your examination-in-chief you said that Varley's first claim was not a claim for a machine, but for a principle, or rather an arrangement for cutting out the bobbins?—*A.* I rather meant the principle as embodied in the arrangement. In his examination he gave several illustrations of what he considered electrical absurdities in Varley's specification. *Q.* Am I right in saying that they are really all a sequel in your view of what you consider an erroneous statement at the top of page 7?—*A.* One of them is not, and of course such as it was, the machine worked irrespective of anything in construction. *Q.* Is it not the case that the machine disclosed in Varley's specification is a workable dynamo machine?—*A.* Yes. *Q.* I suppose you would say it was a good machine?—*A.* I do not know that any at that time could be much better. *Q.* What he does to insulate the bobbins is that at the neutral point he cuts them out of circuit?—*A.* Yes. *Q.* His arrangement shows that?—*A.* Yes. *Q.* That is precisely the same thing that is otherwise done by Haddan in his specification?—*A.* Yes, in a different way. *Q.* Varley said, "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion goes to produce the electric light." You said that passage was not consistent with the series-shunt arrangement?—*A.* Yes. *Q.* Take the first of the two sentences. "Part of the electricity developed by the machine is devoted to maintain the magnetism of the soft-iron magnets." That, I suppose, is consistent with a shunt arrangement?—*A.* It would lead me to think not. *Q.* Is it not true to say "that part of the electricity developed by the machine is diverted to maintain the magnetism"?—*A.* That is true. *Q.* And therefore consistent with a shunt arrangement?—*A.* Yes, so far. *Q.* Is it not also true, speaking of the shunt part of a series-shunt machine?—*A.* Yes. *Q.* Suppose a series-shunt machine, substitute for the first sentence these words, "Part of the electricity is devoted to the shunt." Now is it not true of the series-shunt machine to say that the remaining portion is used to produce the electric light?—*A.* Making that a substitute, it is quite true.—*Q.* How do you reconcile that with your former answer that the sentence was inconsistent with the series-shunt arrangement?—*A.* Because he should then have to read the last sentence as follows:—"The remaining portion is not only used to produce the electric light but to maintain the magnetism of the magnets." *Q.* Reading in the words you say, the current which produced the electric light and maintains the magnetism of the magnets cannot be in any sense said to be diverted?—*A.* No. *Q.* At lines 45 and 46 it says, "The greater portion of the electricity passes through the circuit of larger resistance, maintaining the magnetism of the magnets, and producing the light." Does not that give you the very condition you desiderate?—*A.* It gives me what does not exist in the first sentence, and that was one of the inconsistencies that puzzled me.

LORD TRAYNER: Does it supply you with what is wanting in the first sentence to make it consistent with a series-shunt?—*A.* Yes.

Q. Suppose the first sentence read, "Part of the electricity developed by the machine is devoted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light passing through the circuit of less resistance, which I term the electric-light circuit, maintaining the magnetism of the magnets and producing the electric light," would that have been consistent with a series-shunt arrangement?—*A.* It would. *Q.* What you call inconsistency reduces itself to this, that you find in two sentences what you expected to find in one?—*A.* I think it does. *Q.* Is the "diverting" of the electricity to maintain the magnetism of the magnets consistent with the principle of bifurcation?—*A.* In the language of that day I do not think it would have suggested it. *Q.* Can you suggest any operation to which the word "divert" is so appropriate as the operation of bifurcation?—*A.* Yes. *Q.* What?—*A.* I understand it is not that portion of the circuit current that is bifurcation, but the portion of the electricity in the machine. *Q.* And it is more appropriate to divert the current which is not going into one continued existence rather than taking the portion of the current which has assumed a continuity of existence?—*A.* Yes. *Q.* Haddan, in his specification, said, "I attain my object by devoting from external work a portion of the current in the machine and using it either alone or in connection with the current that works the field-magnets?—*A.* Yes. *Q.* He is describing bifurcation?—*A.* Yes, by diverting part of a current. *Q.* You have been particularly careful to tell us that in Varley's specification you read "electricity" as meaning "current," and not as meaning electric force?—*A.* As electrical currents.

LORD TRAYNER: Take Varley's specification and read, "Part of the electricity," as part of the electric current, developed by the machine, &c.; what does diversion mean? Would it be inconsistent language to describe bifurcation?—*A.* It would not be the usual language, but it would be consistent.

Q. At line 38 of Varley, does electricity mean electric current or electric energy?—*A.* Electricity of the currents.

LORD TRAYNER: If it is not electric current produced in the machine, and not electric energy, what is it?—*A.* Electricity of the currents. I understand he is referring to the armature, which had more coils than one upon it. He would, therefore, have no current, but currents, and divert part of the electricity to go round the field-magnets.

Q. If it is part of the electricity which is diverted, and the thing which is diverted be current, do you not divert the current?—*A.* You divert part of the current. *Q.* The diverted part is in itself a current?—*A.* Yes.

LORD TRAYNER: The machine produced several currents, some for one purpose and some for another, whereas bifurcation is the production of a current at a certain point?—*A.* Yes.

Q. You said the principle of bifurcation was not a thing known to any electric workman; would he know that principle if he happened to know Wheatstone's machine?—*A.* Wheatstone's was a series machine adapted for shunt. *Q.* If a workman happened to know Wheatstone's shunt machine, he would know the principle of bifurcation?—*A.* I cannot answer that. *Q.* Well, Wheatstone's machine arranged in shunt?—*A.* Yes. *Q.* In the same way, if a workman happened to know Clark's patent he would there find the principle of bifurcation?—*A.* Yes; bifurcation was quite common in telegraphy. It was a very simple thing. *Q.* Varley at p. 8 said: "There are several well-known ways of doing this; but the method I prefer is to wrap the soft-iron magnets with two insulated wires, one having a larger resistance than the other." The soft-iron magnets then are field-magnets?—*A.* Yes. *Q.* Is not the idea of field-magnets wrapped with two circuits of wire quite inconsistent with Ladd, Ruhmkorff, and Wilde?—*A.* No. *Q.* Is it not the case that in these three machines the field-magnets are only wrapped with one wire and not with two?—*A.* Yes; but there was an extra wire. There were no drawings in Varley's specification showing the two windings. Taking Varley's commutator, that was inconsistent with separate excitation within the machine. *Q.* Take the passage on p. 8 at line 38, does bifurcation and separate armature excitation exhaust the total possibilities of the machine there described?—*A.* I think I may answer yes. *Q.* If you make a machine, and follow the directions given upon page 8, at line 19, you have told me that that excludes the idea of separate armature excitation—is there anything left except the idea of bifurcation?—*A.* The only possibility is absolutely separate excitation: that was not hinted at. *Q.* Is bifurcation the only remaining idea that is hinted at?—*A.* Bifurcation is not hinted at. *Q.* Can you point to any part of the specification which shows separate armature excitation?—*A.* The only passage is the passage referred to in the previous specification, which had separate armature excitation. *Q.* Are Figs. 3, 5, and 6 inconsistent with separate armature excitation?—*A.* I do not think so. *Q.* Why not?—*A.* Because there is nothing whatever to show how the wires were united to the group of commutators. *Q.* The connections are shown?—*A.* The connection between the bobbins is shown in groups, but nothing further. *Q.* There is nothing to suggest separate excitation?—*A.* There is nothing to suggest how it is to be done at all. Figure 17 in Varley's specification was a series-excitation machine pure and simple, and was of course inconsistent with separate armature excitation. *Q.* You said that a workman at the present day accustomed to machines now in use would read Varley's patent as describing a series-shunt machine?—*A.* Yes. *Q.* Can you reconcile that with your language that the words are inconsistent with a series-shunt machine?—*A.* Yes, because the workman would read the knowledge of the present day into it. Varley had a circuit of greater resistance, which he described as always closed, and according to the idea of the patentee that circuit was always to be kept

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closed; and he put in the circuit the motor of a lamp. *Q.* If you were told, as a matter of fact, that Varley's machine was worked with an arc lamp (the Serrin), and that it was noticed that when the lamp was burning the magnetism of the machine greatly increased, what would that indicate?—*A.* That there was a coil in the circuit of the magnets; in other words, that the machine was at least series-wound. *Q.* If you were also told that when the lamp was out there was still magnetism in the magnets, as evinced by the sparking of the brush, what would that indicate?—*A.* One of three things. First, that there was residual magnetism; second, that there was excitation from some separate source; or, third, that there was shunt-winding. If the lamp motor was to be worked by the electricity in the machine it must be in the series; because, if the contact was made at one of the pulleys the circuit would be opened and the motor would cease. These disadvantages were got over by the arrangement of series-shunt used with the lamp. They then got the motor always working the shunt, which was not liable to be interrupted, and the magnetism maintained in order to supply the series which gave the lamp light. When the lamp went out the motor would begin to work bad, and when the lamp went on the motor would stop working. *Q.* Is not the series-shunt arrangement the best that can be devised for working that particular lamp?—*A.* Taking the commutator of Varley's machine, the segments were riveted on. *Q.* Could the wearing segments be easily taken off?—*A.* That would depend upon the state of the machine and the appliances in hand.

LORD TRAYNER: You could not do it with a quill pen (laughter)?—*A.* No, nor with a screw driver.

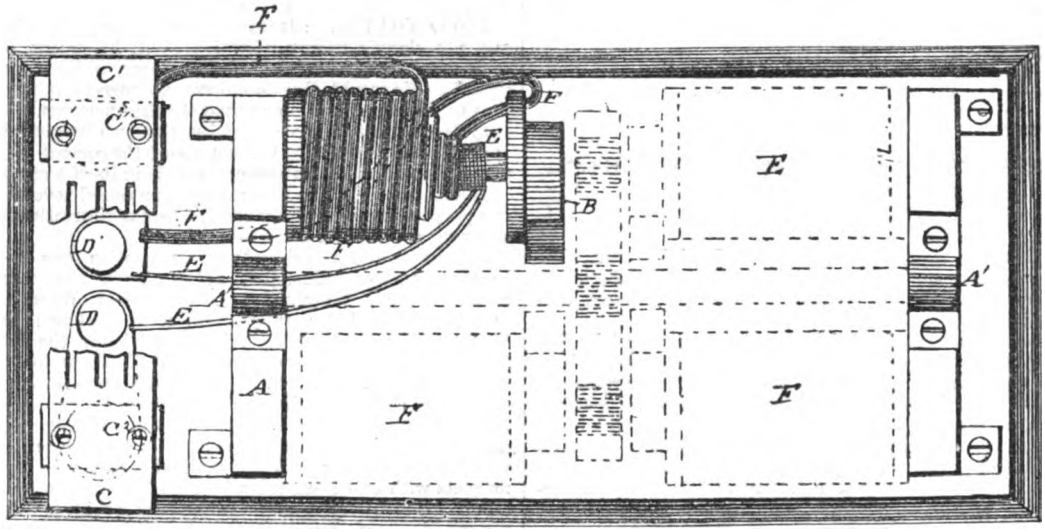
Re-examined by the DEAN of FACULTY: The series-shunt arrangement was preferable to any improvement on the shunt, and Brush indicated that in his specification. *Q.* How is speed reached in the most perfect series-shunt machine now in use?—*A.* It was calculated beforehand, but if you had a machine of a different size you would make a simple trial to reach the amount of speed with a view to maintaining constant potential. A passage in Varley's specification at page 7 provides for separate armature excitation in the case of the number of bobbins being in excess.

Prof. JOHN PERRY, Professor of Applied Mathematical Engineering at the City and Guilds of London Technical College, Finsbury, deposed that he had studied Haddan's specifications and relative drawings with the witness's view of the utility of the series-shunt machine. Both long and short shunt were quite clearly described in the drawings. The description of series-shunt winding was particularly clear, and was fully illustrated by the drawings.

Lord TRAYNER: I do not think there is any question as to the sufficiency of the description in Brush's specification. As I understand it, the question is whether Varley anticipated Brush's description by a disclosure of a shunt machine, and whether the defenders' patent is a new invention.

Mr. GRAHAM MURRAY: The defenders say that one reason why they cannot construe Varley's specification is that he gives no indication of constant potential. I retort that neither does Brush.

Examination continued: Since the date of Brush's specification nothing had been added to what Brush told them in his specification, except that alterations had been made in the dimensions and proportions of different sizes and varieties of dynamo machines. He did not think it possible to draw out a specification to give instructions for making a constant potential machine. Even at the present date, unless he was simply repeating an old machine on the same lines, he would require a certain amount of trial and measurement in order to get an approximation of constant potential. *Q.* Have you examined Brush's specification in order to ascertain whether he describes bifurcation as the method by which he divides his current?—*A.* Yes; and it is quite clear. *Q.* And the drawings absolutely exclude excitation from a separate source internally or externally?—*A.* Yes. He had read Varley's various specifications and the communication made by Prof. Wheatstone to the Royal Society. Wheatstone converted a series machine into what was now known as a shunt machine. *Q.* Did his communication, so far as you know, lead to the manufacture of a single shunt machine?—*A.* No. *Q.* Did it add to the knowledge of electricians in the slightest?—*A.* No. The idea was not put into any practical or useful form, but was a mere suggestion which required to be worked out. *Q.* As a matter of fact, did eminent scientific men so late as 1879 indicate ignorance of Wheatstone's suggestion?—*A.* Yes. Witness never heard of any machine being made according to Clarke's specification. Brush himself was one of the cleverest electricians, and he certainly did not know of it. It was not claimed in his patent. *Q.* In 1876 was there any machine likely to be known to workmen where electricity was divided, except Wilde's, Ladd's



Facsimile copy of Drawing in Haddan's Specification of Brush's Dynamo.

view of giving an opinion as the objections to the utility and the novelty of the invention, and the efficiency of the description in the specification. At the date of Brush's patent there were in use four kinds of dynamo machines—permanent-magnet machines; machines excited from a separate source; series-wound machines; and machines excited by a separate armature or otherwise, from a separate source within the machine. The witness then described the defects of series-shunt and separately excited machines as regards constancy of potential, and explained how these were obviated by compound winding. *Q.* Was that a valuable improvement? *A.* Exceedingly valuable. *Q.* Did Brush purport in his patent to give directions for preparing an absolutely constant potential?—*A.* He does not mention potential at all. The word was not known to electricians or common workmen at that date. What he wanted was a fairly good potential. The approach to constant potential was necessarily a matter of degree. *Q.* Did Brush's invention really supply the means of producing the compensating effect which tends to constant potential in a greater or less degree?—*A.* Yes. *Q.* Does the utility of the series-shunt winding necessarily depend on securing constant potential? *A.* No; its utility begins to be displayed whenever there are two wires compensating one another. Since the date of Brush's patent electroplating had been practised both with the shunt and the series-shunt arrangement. For electroplating the series-shunt arrangement was the most advantageous. It kept the potential constant whether they were plating one spoon or a hundred. That result was not obtained in the same degree with the shunt arrangement. For practical purposes the danger of reversal of polarity was slightly greater in the series-shunt than in the shunt machine. The instance which Mr. Brown had given of a reversal of polarity in a machine in his workshop did not militate against and Ruhmkorff's machines?—*A.* I do not believe there were any. In Varley's specification of 1876 he found no disclosure of the series-shunt arrangements. *Q.* What do you take to be the essential characteristics of the series-shunt arrangement?—*A.* Firstly, the whole of the electricity generated is employed at all times to maintain the magnets; secondly, the electricity divides itself between two circuits, two windings of the magnet; and, thirdly, in its method of division there is a current bifurcated. *Q.* What do you say of the first sentence in Varley's specification?—*A.* He speaks there of part of the electricity developing the machine and the other part being used for the electric light. That is inconsistent with the series-shunt arrangement. The specification certainly excludes any idea of bifurcation. The idea of a shunt was not at all well known then, and the only method was not by bifurcation. *Q.* Taking the passage as a whole, is there any part of it which appears to you to disclose the series-shunt arrangement?—*A.* If it had been written in the present day I should have thought that the latter part disclosed it. The first sentence is quite inconsistent with all that follows. The whole passage is perfectly consistent with separate excitation, and bifurcation is not mentioned. In one place he spoke of two distinct circuits, which was against any idea of bifurcation. It pointed towards an improvement of the Wilde arrangement, or of his own idea of 1867, to which he referred. *Q.* Is your view confirmed by a reference to Varley's previous patent of 1867?—*A.* Yes. He there describes two windings, one coming from a separate portion of the armature. *Q.* Is Varley's specification intelligible as a whole, or is it likely to puzzle or mislead any electrician?—*A.* It is very misleading, and there are many absurdities in it. He had examined Varley's machine, No. 29 of productions. From the number of binding screws on the machine he would say that it was constructed for

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experiments rather than for work. These screws would allow it to be coupled up in almost any way, and could be used as a shunt or a series machine, or as a double-shunt machine. It could also be coupled up as a series-shunt machine.

LORD TRAYNER: It seems to be a very remarkable machine. It can be made to do anything (laughter).

Examination continued: He had examined the models produced by pursuers as being made in accordance with Varley's machine. The one shown him differed in many respects from Varley's patent. Varley's machine required a complicated commutator to work the cutting-out arrangement, and none of the models showed that the excellence in the mechanical construction of the Brush commutator and machine contributed largely to their success. He had examined the commutators of Wilde and Varley, and they did not appear to him at all to anticipate the Brush commutator.

Cross-examined by Mr. GRAHAM MURRAY: Siemens' communication to the Royal Society in 1880 did not give witness the impression that he treated shunt winding as a thing already known. He startled everybody. Every book since 1882 mentioned Wheatstone as the discoverer of shunt. The word "electricity" in a portion of Varley's specification might mean current. The word "divert" might be an appropriate form of expressing bifurcation. *Q.* A machine made according to Varley's specification would, as you say, not be capable of self-excitation, nor with a pure series winding. Would you please tell me what, then, is left except series-shunt?—*A.* For a machine so constructed nowadays we would say it must be a series-shunt, but I do not know what might be said at that time.

The cross-examination of witness was not concluded when the Court rose for the day, to resume on Thursday.

THURSDAY, DECEMBER 6.

Evidence for the defenders was resumed to-day before Lord Trayner.

Prof. JOHN PERRY'S cross-examination was continued by Mr. GRAHAM MURRAY: Varley's machine made by Siebe and Gorman, as it stood, could not be used as a series-shunt machine, but it could be connected up to be so used. It would be a perfectly natural way now of connecting that machine.

Re-examined.—With reference to the word "divert" in Varley's specification, the meaning which he thought a workman would have attached to it in 1876 would be to divert the electricity. He would have taken the idea of separate-circuit excitation, and not bifurcation. *Q.* Is it part of your objection to Varley's specification as a prior disclosure that it would form a puzzle to any electrical workman seeking to construe it?—*A.* Yes. *Q.* What, in your view, would be the arrangement which would make the nearest approach to a reconciliation of all the different passages?—*A.* I think separate-circuit excitation.

ALFRED HICKS, overseer of the *Graphic* Illustrated Newspaper Company's electrotyping foundry, deposed that the dynamo purchased by that firm from the Anglo-American Brush Company in 1883 had been put to work upon electrotyping, and during the five years there had been no difficulty due to the reversal of the poles of the machine. It had always worked satisfactorily.

Sir WM. THOMSON deposed that in his opinion the Brush series shunt-winding arrangement was a marked and valuable improvement upon previous arrangements. In particular, it was a valuable improvement upon the shunt and upon the series. The description in Brush's specification was such as would enable an ordinary workman to obtain the benefits of the invention without any difficulty. At the date of the Brush patent he did not think the shunt arrangement was known in practice; because he heard it first in consequence of Dr. Siemens's communication about 1879. He believed he himself had the first practical shunt machine for electric lighting; he got the machine from Dr. Siemens with some difficulty. He did not know of the shunt arrangement till 1879. He believed the series arrangement was in common use in 1876, and he knew it was in 1880. The arrangement in which the electricity was obtained from a separate source within the machine was in common use in 1876. That was an arrangement of which Wilde's machine might be taken as a type. He believed that what was now called compound winding was not known at all, even to scientific men, in 1876. Taking a passage in Varley's specification, he did not think that any electrical workman in 1876, reading that passage, would have had disclosed to him the system of series-shunt winding. The specification would have puzzled him. The puzzles were precisely such as would be apt to mislead an ordinary workman. For example, take the first sentence: "A part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets." He did not think it quite clear how the part was to be obtained. The workman of that time would consider how he was to get a part of the electricity and divert it from the desired external work of the machine, to sustain the power of the magnets. Then he said, "the remaining portion is used to produce the electric light." If it was divided into two parts in some way that would be clear enough, provided the remaining portion was used simply to produce the electric light; but the reader was led off the idea that the remaining portion contributed in any way to the magnetism of the magnets. Part was diverted to maintain the magnetism of the magnets, and the remaining portion was used to produce the electric light, so that the reader would be led to understand that it was used only to produce the electric light. Then he said, "There are several well-known ways of doing this, but the method I prefer is to wrap the soft-iron magnets with two insulated wires, one having a larger resistance than the other." That was not the way of doing that which was specified in the first sentence, and so the reader became very much puzzled. A new idea seemed introduced there inconsistent with the first sentence. Then he went on to say "The circuit of larger resistance was always closed, and the circuit of less resistance is used for the electric light." These words certainly would imply to the reader then—and, he thought, to the reader now—taking these words, and not thinking of compound winding, which he knows from subsequent disclosures—they would imply two circuits, the one a complete circuit of larger resistance which was always closed, and another distinct circuit of less resistance which was used for the electric light. When he spoke of two complete circuits, he meant two separate circuits. If there was to be electricity given through each circuit, there must be a source for each circuit. *Q.* By two separate sources, and not one source bifurcated?—*A.* Yes; I think the natural interpretation is two separate sources, and not two branches of one. The proper words for bifurcation would be a branch of less resistance, and not a circuit. [Shown Varley's machine made by Siebe and Gorman.] He observed that that machine had twelve terminals and a number of loose wires, and he saw that there were both thick and thin wires on the same magnets. It appeared to him to be an experimental machine, and one reason for that was the unusual number of terminals and loose wires, which permitted of various methods of coupling-up being tried. He supposed the machine could be coupled up so as to be used as series-shunt, as series, as shunt, or as double shunt; but taking it as he found it, he thought it was not possible to say how it was used. He had studied the parts of Haddan's provisional specification relative to the commutators, and the descriptions in the final specification, as also the claims applicable to the commutators. The claims in the final specification did not go at all beyond a fair carrying out of the invention disclosed in the provisional specification. The Manchester commutator did not strike him as being at all an anticipation of the Brush arrangement, or of any of those claims, because the mode of fixing on the wearing segment was different from Brush's.

Cross-examined: Shunt-winding was not really known till about 1879 or 1880. Wheatstone disclosed it in his communication to the Royal Society, but not clearly. He could scarcely consider that communication, in which a short wire was put across between two poles of the circuit, as being anything like a disclosure of shunt winding. It was virtually a current used in an external circuit while the magnet was excited by a shunt, and so it was a shunt arrangement. It was treated as a shunt arrangement even by Siemens. It struck him that rather more credit was given to Wheatstone than he deserved in that particular matter, which was really of no moment to his fame. Siemens treated shunt as a thing which had been disclosed by Wheatstone. Clark's patent disclosed it with more clearness. Bifurcation of an electric current by splitting or joining two wires in one was a very common thing, and had been so for a very long time in telegraphy. An electrical workman might bifurcate a current, and splitting the wire would readily suggest itself. *Q.* Do you read electricity as meaning electric energy or electric current?—*A.* I do not know. I may say further that it would make no difference to me whether it was called electricity or electric energy, or electric current, in construing this sentence. If electricity meant electric energy, it would be true to say of a series-shunt machine that part of the electric energy was depleted to maintain the magnetism of the magnets, and the remaining portion was used only to produce the electric light. *Q.* Taking it as electric current, if you do not read in the word "only," is not the language consistent with what occurs in a series-shunt machine?—*A.* It is not absolutely contradictory, but the first sentence is very misleading. It was true to say of a series-shunt machine that the portion of the electric current which was not used in the shunt did maintain the electric light. That was true so far as it went, but it also did something else. *Q.* Does not a subsequent sentence give you the additional function which it was to perform if it was series-shunt over and above the producing of the electric light?—*A.* That implies that the current through which the electric light is maintained does pass round the electric magnets. That is consistent with, and, indeed, indicative of, the series portion of a series-shunt machine. There were just two portions dealt with in preceding lines—first, the part which is diverted, and, secondly, the remaining portion which is used to produce the light. These two are exhaustive of the whole. *Q.* Is not the first portion which is diverted consistent only with either shunt or separate excitation? *A.* I think it must be held to mean either the one or the other. I cannot suggest anything else it could mean. *Q.* Does that not leave this difference, that when I add to the first sentence the second sentence I get it that the machine there described must be a machine which has an excitation of the magnets by a series arrangement, and has also excitation of the magnets either by a shunt arrangement or by a separate excitation within the armature?—*A.* Either by a shunt arrangement or by an arrangement in a separate circuit. *Q.* And practically the action of the shunt would be equivalent to the action of the separate excitation?—*A.* Not quite equivalent. They are far from being equivalent. He thought the words used by Varley implied two circuits. He noticed that Brush used precisely the same term, because "circuit" was continually being used for "branch" by writers on that subject; it was an ambiguity. With reference to commutators, Varley said, "when electricity of a very high potential is desired, the commutators may be increased to the same number as the bobbins." That pointed to series among the bobbins in case of high potential being desired. With a machine where the commutators were all connected in series, the idea of separate excitation was not necessarily excluded, because one group might be kept out of the series. If they were all in series separate excitation was kept out. With regard to those passages of Varley where something was said about the results of storing magnetic force and so on, those matters were very much among the *arcana* of the science, and were made more so by the words that were often used. *Q.* If you were describing these operations now, would you necessarily be quite correct according to the scientific knowledge of 1898?—*A.* I hope not. *Q.* In that matter about the storing of magnetism, assuming Varley was wrong in what he says, that would not make any difference upon the working of the machine?—*A.* One of his chief claims is founded upon an idea which, I think, must generally be admitted to be erroneous; that is his first claim. *Q.* You think Varley's actual apparatus for cutting out the armature bobbin at a certain part is not so complete as Brush's was afterwards, because it did not cut it out for long?—*A.* I think

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probably it would not be so well proportioned as it would have been if that wrong theoretical idea had not influenced him. *Q.* Does not that cutting out of the bobbin at a neutral point, as it is done in Varley, act satisfactorily so far, though it would have acted more satisfactorily if you had cut it out for a little bit longer?—*A.* I think so. *Q.* If you were told as a fact that Varley's machine, No. 29 of productions, had been connected in accordance with the device shown in Varley's sketch, would that convey to your mind a certainty that it had been worked as a series-shunt machine?—*A.* Yes. *Q.* Without being told how it was connected, if you were told that that machine was worked with the lamp produced, and that it was noticed that when the lamp was lighted the magnetism of the machine was greatly increased from what it had been before, would that convey to your mind that this lamp was used in connection with the series-coil of this machine?—*A.* Yes. *Q.* If you were also told that when the lamp was out the magnets of the machine were noticed to be excited, as evidenced by keys and so on sticking to them, and by sparking at the brushes, would that indicate to your mind that the magnets of this machine, besides being excited by the series arrangement, were also excited either by the shunt or a separate excitation arrangement?—*A.* No; because residual magnetism may be amply sufficient to produce these effects.

WM. HENRY PREECE, electrician to the General Post Office, deposed that his attention was first called to a shunt-wound machine by a Paper read by Sir Wm. Siemens before the Royal Society in 1880. He was aware that Sir Charles Wheatstone had read a Paper developing the idea of shunt before that, but he simply alluded to the experimental use of shunt, and did not in any way indicate the construction of a shunt machine. He had since heard of Clark's patent, but he had not heard of it before 1880. So far as he knew, no machine had been made in conformity with that patent before 1880. He had examined Varley's machine, No. 29 of productions. It was a very complicated machine, which would have an excessive waste of electric energy. If that machine were used to excite an electric light with the lamp now produced, it would require about 4-horse power, and of that 3½ would be wasted in the machine, and only one-half horse power would be employed in generating the light. He thought it would have been extremly difficult, if not absolutely impossible, for a workman in 1876 to have made a series-shunt machine from the directions contained in Varley's specification. The whole thing was really an improvement upon a machine that existed and was patented before by Varley. The drawings were scarcely consistent with the letter press. The part of the specification dealing with the question of winding with two wires was certainly inconsistent with the rest of the specification. There were two-pole machines, four-pole machines, and six-pole machines, and they were all referred to as though they were ordinary series-wound machines. When they came to the specification dealing with the question of two wires, they found something that was not consistent with anything else that appeared in the specification, but it was to some extent consistent with something that appeared in Varley's previous specification. It was very well known about that period that Holmes and Wilde excited their machines by a separate circuit taken from a part of the armature. The wrapping of magnets with two wires was not a novelty in 1876; it was a most common form of apparatus, especially in telegraphy. *Q.* Taking an ordinary series-shunt machine, as described in Brush's specification, the description about the wrapping of the magnets would not lead necessarily to the construction of a series shunt-machine?—*A.* It would depend upon how the wires were connected, and where they got the electricity from. These matters were left entirely indefinite in Varley's specification. The machine described in Haddan's specification was undoubtedly a useful machine, and was a decided improvement upon either the series or the shunt. He thought that from the specification a workman would have no difficulty in constructing a machine of the nature there described. He thought that sheet four of the drawings, taken with the directions in the specification, would lead to the making of a machine which would tend to constant potential. Brush's specification completely disclosed the invention of series-shunt winding. It would be quite impossible in such a specification to give directions which would enable a workman to make every type and variety of machine to produce electricity at constant potential. Even at the present day, and in view of all the knowledge acquired since 1878, it was usual to have trials, to see whether the machine was properly compensated. The machine described in Haddan's specification was a compensating machine. He had on 4th February, 1887, made some experiments with the early Brush compound-wound machine for electro-plating. The current varied during the experiments from 300 amperes, which was a very large current, to nothing, and the potential remained very fairly constant. There was a variation between the extreme load and no load of 22 per cent.

Cross-examined: So far as constant potential was now understood, and as desired for the incandescent light, they would not dream of accepting a machine with 22 per cent. variation. At Messrs. Crompton's works they could nowadays make pure shunt machines which they would guarantee to within 10 per cent. of constant potential. The usual specification limit was 5 per cent. in series-shunt machines. Compensation in electro-plating would be got by a pure shunt machine, but not to the same extent as in a series-shunt machine. In making the calculation as to the economy of Varley's machine he had assumed that it was connected up as a series-shunt machine. *Q.* Taking Varley's machine at its own date, and not in view of the machines that had been since discovered, was it such a bad machine when Varley invented it?—*A.* I should say that if it was chucked on the dust heap it must have been rather a poor thing. *Q.* Do you think it was a poor machine in 1876?—*A.* I think if it had not been a poor machine we should have heard something about it. He did not express an opinion about the efficiency or non-efficiency of Wilde's machine. He had never devoted his attention to finding out what was the percentage of waste in the earlier machines, such as Wilde's, Ladd's, and Ruhmkorff's. He could not say whether Varley's machine wasted more or less than they did. *Q.* Is there any reason why a machine which has three bobbins to each group should not be a series shunt-wound machine?—*A.* It would not be at all consistent with what follows. *Q.* But what is inconsistent in that with the idea of the machine being wound series-shunt as regards the field-magnets?—*A.* That can only possibly refer to one circuit, whether series or shunt; it does not say a word about an armature circuit. He was obliged to take this matter in connection with the previous machine of Varley, and in his patent of 1867 he distinctly defined how the field-magnets and bobbins were to be wound. The 1876 specification simply described the commutators of the machine, and made no reference to the field-magnets.

Re-examined: Figure 17, sheet 3, of Varley's drawings showed the arrangement of the commutators described in the specification. The winding was series winding. No other sort of winding was shown.

ROBERT PERCY SELLON, chief electrician of the Anglo-American Brush Electric Light Corporation, said the patent now in question was purchased by the defenders in December, 1880, from a previous company, who had purchased it from Brush in 1879. The price paid to Brush for the English and Colonial patents was £27,000, and the price paid by the present company for the English patent was £25,000. The patent had been twice amended by disclaimer, in 1882 and 1885. The series-shunt-wound system, according to the Brush patent, was introduced immediately upon the formation of the original company in the end of 1879. For electro-plating the Brush Company commenced to supply series-shunt machines in 1880, and they had supplied them continuously since. All the machines sent over from Brush between 1880 and 1883, and used for electro-plating and electro-typing, had been subjected to test, and it was found that they maintained the potential constant to within 15 or 20 per cent. He had examined the proportions of the windings of some of the machines, and they were very similar to the proportions shown on Brush's drawings. Up to the summer of 1882 witness knew of no series-shunt dynamo in the market for any purpose whatever, with the exception of those supplied by the Brush Company under their patent. The first dynamos that were made specially for incandescent lamps were constructed by Brush in July, 1882. In the summer of 1883 the Brush Com-

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
VULCAN PHOSPHOR DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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pany in England commenced to supply series-shunt machines specially for incandescent lighting. It was in 1884 or 1885 that the Brush Company first discovered that their patent was being seriously infringed, and they insisted on licenses being taken. Messrs. Siemens and twenty-two of the leading manufacturers in the country had taken licenses. The only persons who contested their rights were Messrs. Crompton and several minor firms. An action was brought against Messrs. Crompton for infringing the patent right, and in 1887 they consented to judgment, paid £2,000 costs and damages, and accepted licenses, the Brush Company giving them a rebate of practically one-fourth in consideration of their assigning to the company a subsequent patent on the same subject of series-shunt. The only other litigation upon the patent was an action by the Brush Company against the Orient Company, in which judgment was given for the pursuers. As regarded their commutators, their claims were merely carrying out in detail, and in various combinations, the inventions foreshadowed in the provisional specification. Claim 6 said nothing about the insulating segment "T" being metallic. It was a claim for the combination of details all tending to simplify the mechanical construction of the commutator, diminishing the number of gaps, and making it more cylindrical, durable, and simple.

Cross-examined: [Shown statement of the stock of the Brush Company at May, 1883.] That list showed no series-shunt-wound machines in stock. He did not know how much of the £27,000 paid by the original company was paid to Brush himself. *Q.* You do not know whether he only got about £6,000?—*A.* I do not suppose he got the whole, because there was a second party who was taking part in the sale.

This closed the proof for defenders, with the exception of the evidence of Mr. Brush, which is to be taken in America by commission. Counsel will afterwards be heard, and the judgment of the Court will probably be given before the end of January.

United Telephone Company v. Ericsson-Bell Telephone Company.

On Tuesday last Lord Trayner closed the record in an action at the instance of the United Telephone Company, London, against the Ericsson-Bell Telephone Company and Charles Bell, the only known partner of that firm, which carries on business at 29, Waterloo-street, Glasgow. The pursuers ask that defender should be interdicted from infringing letters patent assigned them by the Edison Telephone Company in 1880, and by Alexander Graham Bell, Boston, in 1878. There are also conclusions for £1,000 damages, and that defenders should deliver up all the instruments which have been constructed in infringement of pursuers' letters-patent. The defender had a stall in the recent International Exhibition in Glasgow, and the pursuers aver that he sold instruments there which were an infringement of their patents. The defence is a denial of the infringement, and defender pleads that the damages claimed are excessive.

United Telephone Company (Limited) v. Edward Paterson.

This action came on for hearing before Mr. Justice Chitty, on the 4th inst. The plaintiffs asked for an injunction against the defendant, who carries on business at the European Works, Pownall-road, Dalston, for infringement both of the Edison and of the Bell patents.

Mr. MACRORY, who appeared for the defendant, admitted the infringement and submitted to an injunction in the usual form, and to an order directing the defendant to deliver up all infringing instruments in his possession or under his control, and directing an inquiry in chambers as to the damages sustained by the plaintiffs, the defendant to pay the costs of action.

The plaintiffs claimed their full costs, charges and expenses, as between solicitor and client, under the 31st section of the Patent Act, on the ground that they held certificates that the validity of the patents had been questioned in previous actions, but Mr. Macrory, on behalf of the defendant, argued that the plaintiffs ought not to have their full costs in this case, and asked the judge, under the 31st section, to certify to this effect.

Mr. JUSTICE CHITTY remarked that the defendant had on his own admission infringed the patents, and that he saw no reason for depriving the plaintiffs of the full costs which the statute gave them.

COMPANIES' MEETINGS & REPORTS.

The Swan United Electric Light Company (Limited).

The following is the sixth annual report of the Directors, to be presented at the ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, E.C., on Tuesday, December 18, at 12 noon:—

1. The accounts which are presented to the shareholders are for the year ending 30th September, 1888.

2. The business has increased on the Continent generally, and has resulted, after paying all current charges and making fair allowance for depreciation of plant and machinery, in leaving a credit balance of £8,332. 1s., which the Directors will recommend shall be carried forward.

3. The agreement with the Compagnie Continentale Edison, which was unanimously approved by the shareholders at the extraordinary general meeting, held on 5th June last, was also approved by the shareholders of the Compagnie Continentale Edison, and has resulted in the formation of the Compagnie Générale des Lampes Incandescentes, which has its seat in Paris, and who are erecting a factory with all necessary appliances for a large output of lamps to meet the established and growing demand.

4. The litigation as to the Swan and the Edison patents is still dragging on in Germany. The negotiations between the Company and the representatives of the Edison patents in Germany have been dropped for some time, but the Directors will avail themselves of any fair opportunity which may be afforded of re-opening the negotiations with a view to a satisfactory settlement in Germany.

5. The Directors who retire by rotation are Mr. J. W. Swan and Mr. C. H. Stearn.

6. Messrs. Quilter, Welton and Co., the auditors, also retire.

Woodhouse and Rawson (Limited).

An extraordinary general meeting of this company will be held at the Cannon-street Hotel, Cannon-street, E.C., this day (Friday, December 14), at 3 o'clock, for the purpose of considering, and, if thought fit, passing, a resolution for the sale of the property of this company to a larger company now in course of formation. A temporary auditor will be appointed.

CITY NOTES, &c.

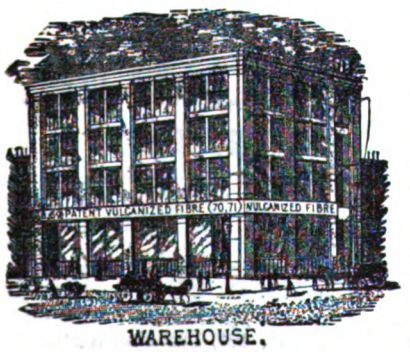
BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 7th, 1888, amounted to £5,917.

RIVER PLATE TELEPHONE AND ELECTRIC LIGHT COMPANY (LIMITED) (IN LIQUIDATION).—Holders of share warrants to bearer in this company are requested to send in their warrants forthwith to the liquidators at the offices of the company, New Broad-street, E.C., in order that the payment due thereon may be made before the liquidation is closed. Otherwise application to the Court of Chancery for payment will be necessary.

THE MINING AND GENERAL ELECTRIC LAMP COMPANY (LIMITED).—Lord Crawford writes to the *Financial News* as follows:—"Sir: I observed in Wednesday's papers a notice that the shares of this company were allotted. I think it only right, as my name and the names of my friends, the Hon. Reginald Brougham and Mr. James G. Stephen, were on the prospectus, that the public should know we had resigned our seats at the board prior to the allotment.—I am, sir, yours, &c., CRAWFORD, 2, Cavendish-square, W."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 7th, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4,905.

THE NON-CONDUCTOR OF ELECTRICITY.



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This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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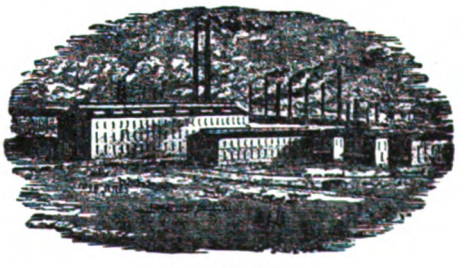
Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Dec. 12, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Dec. 12, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	46½ 47⅛	2 17 11	Jan., Apr., July, Oct.	47⅜	45¼
2,614,820	Stock	15/0	Do. Preferred	78½ 79½	3 9 2	,, ,,	79⅜	76½
2,614,820	Stock	nil.	Do. Deferred	15⅝ 16¼	...	February	16⅜	14⅜
130,000	£10	5/0	Brazilian Submarine	13⅛ 13⅜	5 4 8	Mar., June, Oct., Dec.	13⅜	13,⅜
16,000	10	9/0	Cuba Submarine	14 14½	5 17 3	February and August	14¼	14
6,000	10	10/0	Do. Preference 10%	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4⅛	3 11 1	March & September	...	...
6,000	5	5/0	Do. Preference 10%	9 10	5 0 0	April and October	...	...
60,710	20	2/0	Direct United States	9⅛ 9¼	4 2 1	Jan., Apr., July, Oct.	9⅛	...
380,000	10	2/6	Eastern	12 12½	4 18 0	,, ,,	12½	12⅛
70,000	10	3/0	Do. 6 per Cent. Preference	14¾ 15¼	3 19 0	,, ,,	14⅝	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	...	...
250,000	10	2/6	Eastern Extension	12⅝ 12⅞	5 2 0	Jan., Apr., July, Oct.	12⅞	12⅞
22,050	10	8/3	German Union Telegraph and Trust	9 9⅛	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6¾ 7	5 7 2	Jan., Apr., July, Oct.	6¾	6⅞
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 3 6	,, ,,	14⅜	14⅛
150,000	10	5/0	Great Northern	14½ 15	5 0 0	Jan., July, and April	15	14⅜
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
38,348	10	3/0	London Platino Brazilian	7½ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7	5 10 6	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98	...
30,000	10	6/0	West Coast of America	9 9½	5 5 3	January and July	9⅜	9¼
150,000	100	8%	Do. Debentures 8%	121 125	6 8 0	June and December	12⅝	...
83,321	10	1% '78	West India and Panama	1⅝ 1⅞	...	...	1⅞	1⅛
31,563	10	12/0*	Do. 1st Preference 6%	11½ 12	5 0 0	April and October	11⅞	11½
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	13⅛ 13⅜	5 12 2	March & September	13⅛	12⅝
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	⅛ ⅛	5 10 0	Yearly	...	...
220,000	£1	2½% '87	Oriental (11s. paid)	⅜ ⅜	2 14 11	...	⅜	...
80,000	5	5/0	United	13¾ 14¼	5 5 3	June and December	14⅛	13⅞
55,000	5	4/6	United River Plate	5⅝ 5⅞	...	January and July	5⅞	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4 4⅛	...	...	...	...
23,692	5	nil.	Do. (fully paid)	5 5⅛	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2½ 2⅝	...	...	2⅝	2⅜
312,000	¼	5% '86	Maxim-Weston	1/16 1/8	...	February	1/16	...
			MISCELLANEOUS.					
87,350	12	36/0	Telegraph Construction and Maintenance	40 41	5 17 2	March and July	40¼	40
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17 17⅛	5 14 3	February & August	...	...

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 553.—Vol. XXII. FRIDAY, DECEMBER 21, 1888. Price 4d.

NOTES.

The Vestry of Paddington can hardly fail to have been considerably surprised on learning from Mr. Mackie that a profit ranging from 37 to 50 per cent. upon the capital invested may be looked for in connection with the proposed electric lighting scheme in that district, and the ratepayers will probably much lament the fact that so considerable a source of revenue has been so long untouched. It is true that Mr. Mackie is perfectly honest in setting forth the very special conditions under which this delightful result may be looked for, but in a report prepared for the public consumption it would, we think, have been better to have made it quite clear that the condition in question is wholly chimerical and unattainable. No electrical engineer requires to be told that to estimate for central station lighting on the basis of a total annual output of 2,186 hours under full load is preposterous; but the Paddington Vestry may not be aware of the fact, and therefore we think that Mr. Mackie ought to have told them so. A more reasonable basis of calculation would be about two-fifths of Mr. Mackie's figure, or, say, 875 hours per annum. If the estimated revenue from incandescent lighting be reduced in this proportion, and the same reduction be made in the working expenses so far as they are affected thereby, then accepting the remainder of Mr. Mackie's figures, it appears that with a tariff of 7¼d. per B. T. unit the investment will not even pay the 5 per cent. interest on the borrowed capital. There are other details upon which the estimates are open to criticism, but we will only stay to inquire whether £100 (less than 1 per cent.) is a reasonable allowance for "contingencies" on an expenditure (in Scheme A) amounting to over £10,000?

Mr. Mackie has evidently gone to very considerable trouble in the preparation of these estimates, and we therefore the more regret that he should have based the revenue estimate upon such totally erroneous assumptions. And we feel bound to express our objection to the presentation of documents of this description, which can only do harm to the progress of electric lighting. Fortunately in this case we have reason to suppose that very little injury can result, since the Vestry will no doubt await the report of Prof. Forbes before taking further action.

From a letter in another column it will be seen that Dr. Oliver Lodge declares himself a disbeliever in the so-called abnormal magnetisation which is frequently alleged to occur with Leyden jar discharges. In a long series of experiments Dr. Lodge invariably found the magnetisation of a normal character. This is admittedly strange, in face of the fact that so many observers have come to the contrary conclusion. We may suppose, however, that the experiments in question were primarily directed to ascertaining the magnetic permeability of steel under oscillations of varying frequencies (*see* Dr. Lodge's Papers on "Lightning Conductors," in our last two issues). If so, it is just possible that the permanent conditions of the experiment happened to be such as to produce uniformity, and that with more varied conditions a less uniform result would have been attained. It will not be forgotten that a possible explanation of the latter effect was recently given by Prof. Ewing.

The introduction of the Waterhouse constant-current dynamo has drawn attention to the method of obtaining regulation by the aid of a third brush, whose position on the commutator is adjusted automatically or otherwise. In a Paper "On the Regulation of Dynamos by Means of a Third Brush," Mr. E. Caldwell recounts a series of experiments which he has carried out at the Cornell University in order to elucidate the theory of this effect. In this somewhat remarkable Paper it is shown that a simple explanation can be given of all the changes which occur when either the position of the brush or the resistance in circuit with it are subject to variation, and what are the conditions necessary for constant-current regulation. He remarks that the arrangement is really equivalent to a machine in which one set of field coils is made to do duty for both shunt and series winding, and, moreover, the shunt coil or its equivalent acts either as a cumulative or differential coil, according to circumstances. In the experiments described it appears that it was found necessary to alter the position of the brush or of the resistance connected thereto, and so far we have no radical improvement upon other well-known methods of constant-current regulation in which brush movement or field circuit regulation is necessary.

In the second part of the Paper the author points out that the "third-brush" method may also be used as a means of maintaining constant potential, and he claims for this arrangement the further advantage that the brush may be fixed in position, and that the resistance in circuit with it may be also fixed. The importance of this suggestion is so evident that its validity merits careful examination. We do not for a moment dispute that the effect described by Mr. Caldwell was

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obtained, and is obtainable. But, unfortunately, the experiments seem to have been carried out upon an old-fashioned machine of small size, and the author has apparently overlooked the fact that the result described must have been in reality due to prejudicial inductions in the armature, such as were first elucidated by Mr. MORDEY in his well-known investigation of the early Schuckert machines. In fact, as Mr. MORDEY has himself suggested to us, very little consideration is sufficient to show that a current through the third brush, varying on either side of zero according to the total current generated, can only be accounted for by the existence of a variable equipotential point on the commutator. That is to say, the distortion produced by the armature current is so great as to entirely upset the conditions of potential distribution upon the commutator which should prevail in any well-designed dynamo. The mere fact that a third brush can be placed on the commutator at a point between the main brushes may be taken as sufficient evidence that the distribution of potential is abnormal and bad; for if no excessive sparking occurs at the third brush, it can only be because this brush is at a false neutral point. Had Mr. CALDWELL conducted his experiments on any good type of modern dynamo built for incandescent lighting, he would certainly have been unable to obtain the regulating effects that he describes; and we very much doubt whether the disadvantages accompanying the design are counterbalanced by the possession of such a method of regulation. In the case of constant-current machines designed for arc lighting, we do not say that the method is necessarily bad in practice.

A FEW days ago we witnessed a repetition of an experiment which was lately shown by the London Electric Supply Company to the representatives of the Board of Trade, and which may, perhaps, tend to reassure those who regard high-tension currents with an unnecessary degree of dread. One lead of a 2,500-volt alternating-current circuit was carefully placed to earth in damp soil, and it was shown that no danger was incurred, and, indeed, very little sensation was experienced, by touching the other lead, even when the experimenter himself stood on damp soil. The second lead was old and weather-worn, and had been in use for some three years, so that the experiment may be said to have taken place under very rigorous conditions. The presence of the 2,500 volts was made visible by stringing twenty-five 100-volt incandescents across the wires. The existence of a circuit to earth was also shown by the sparking which took place on grounding the lead. It is to be hoped that the Board of Trade will see reason in this for insisting upon good workmanship and materials, rather than for imposing any arbitrary limit of potential difference.

IT is decidedly unpleasant, not to say alarming, to have your telephone burnt out by a "cross" with an electric lighting wire; but seeing how easily and cheaply all danger of such a disaster may be averted, there is no real occasion for the state of terror and alarm under the influence of which the writer of a letter in the *Standard* was evidently labouring. The insertion of a safety fuse (costing a few pence only) will provide a perfect remedy, even in the event of a cross—which, of course, ought never to occur—by some mishap occurring. We may note further that since all electric light wires are covered with insulation, it does not necessarily follow that any damage will result even if the wires do come in contact. The United Telephone Company will, however, do well to put in safety plugs for all their subscribers whose wires traverse the electric lighting area, and there will be an end of the matter. Considering that over a hundred miles of overhead high-tension circuit exists in London, the fact that this is the first accident of the kind speaks volumes for the care and skill with which both telephone and electric lighting wires are now erected.

As to the actual facts of the case in point, we learn that the mishap occurred in Berners-street, where a wire from Messrs. PRITCHETT'S lighting station crossed the telephone wire at right angles, the latter being underneath. Contact by some means having been established, the telephone wire was burnt in two, and the telephone coils were frizzled up. The end of the wire seems to have fallen across a line belonging to the Exchange Telegraph Company, and the "sparks which flew across the room," and the "shock" felt by the lineman, were caused by the Exchange Company's current, and had nothing to do with the electric light wire. Of course the lineman was not hurt, and gives a very different version from that of the *Standard* correspondent. In the Telephone Exchange an indicator was frizzled.

MUCH anxiety is evinced in Parliament by certain noisy members lest the Government should pay more than the price of old iron for the cables of the moribund Submarine Telegraph Company. It is an ugly sign of the times when public men, otherwise honest and sensible, allow themselves to employ language worthy only of the Commune. The ostensible pretext is to prevent the tariff being kept too high because of a fancy price having been paid for the lines. But that is not at all likely to happen. A fair price, however, ought certainly to be paid for a system of cables which still represents a "going concern," although not an exclusive one. Members of Parliament should remember that, if the monopoly expired, the Company did not, and to extinguish it compulsorily in the interests of the public a liberal bonus on the working plant ought not to be begrudged.

WITH the discouragement of Barnet to contend against, it is well to remind the public that for one station which is a failure there are at the present time in operation in this country no less than twenty-three central electric lighting stations, almost all of which are perfectly successful in every sense of the word. As one of the most striking examples, we may mention the Thomson-Houston plant which has been run for the last two years by Messrs. TASKER, SONS AND Co. at Sheffield, and which has from the very first worked without a single hitch. At the present time over 100 2,000 candle-power arc lamps are supplied from three 50-light machines, and a 600-light Mordey alternate-current transformer plant for incandescent lighting will be ready for use at the beginning of the year. As an

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illustration of the steadiness of the arc lighting, we may mention that two billiard tables have been so lit from the commencement, and perfect satisfaction is expressed.

REPRINTING a recent leader of ours, entitled "Electricity our Defence," the *Electrical Review* of New York reproachfully reminds us that the title we borrowed, with a compliment to the "American press" for its felicity, was the *Review's* very own, adding these significant words, "The name of this journal is not the 'American Press.' Does our neighbor see the point?" If our neighbour will pardon us for saying so, we rather think there is more handle than point to this complaint. We certainly paid a high compliment to the newspaper in question—much higher than if we had mentioned it by name. On reflection, probably, our contemporary will see the point of *that* remark.

The Berne-Geneva Telephone Line.—Direct telephonic communication between Berne and Geneva has just been opened.

Vienna.—A company has recently been floated in Vienna with a capital of a million florins for the purpose of constructing a central lighting station in the Mariahilf quarter.

Church Lighting in London.—We understand that the Metropolitan Electric Supply Company has offered to light St. Martin's Church, at Charing-cross, by electricity. The Oratory at Brompton has been so lighted for some time.

Chelsea.—At a meeting of the Chelsea Vestry last week, the Surveyor, Mr. Strachan, reported that the Chelsea Electric Supply Company proposed building their central station in Draycott-place, with a basement below the level of the street sewer.

Electric Lamps for Locomotives.—Good results having been obtained with the electric lights used on the locomotives of the Berlin-Stralauer-Rummelsburg line, it has been decided to extend their use to the locomotives on the railway running round Berlin.

The Eastern Cable Companies.—We have received a very neat and extremely useful paper cutter, on which, besides an almanac for 1889, the cable systems of the world are clearly depicted, issued by the Eastern and Eastern Extension Telegraph Companies.

Southwark.—At a meeting of St. Olave's District Board of Works last week it was resolved not to comply with a request from the House-to-House Electric Supply Company (Limited) to assist them in obtaining a license to supply the district with the electric light.

Pordenone.—On the 23rd September the central station at Pordenone (Italy) started work. The station is 2½ kilometres outside the town, and power is furnished by a 30 horse-power Girard turbine. At present only 280 incandescent lamps, run off three Zipernowsky-Déri transformers, are in operation.

Suakin.—A *Standard* telegram from Suakim says:—"Engineer White, of Her Majesty's ship 'Racer,' and Engineer Mason, have just completed an installation of the electric light at various points of Quarantine Island, including the hospitals there. A trial has been made, and the system has been found to work satisfactorily."

The Transvaal Telegraphs.—We learn that the Transvaal telegraph system is at present almost in a state of collapse, the mail service generally beating the wire. Mr. Sivewright, the well-known telegraph engineer of Cape Town, is now on his way to the country to see what can be done in the interests of the Eastern Telegraph Company's customers.

The Telephone on the West Coast of Africa.—The St. Paul-de-Loanda Telephone Exchange has nearly 100 subscribers, chiefly merchants and Government officials. The telegraph line between Loanda and Dondo, a distance of 125 miles, is almost exclusively used by the English, and affords great facilities to the planters in the interior.

Rotherhithe.—At a meeting of the Rotherhithe Vestry last week a letter was read from Messrs. Deacon, Gibson and Medcalf, on behalf of the Electric Supply Corporation (Limited), stating their intention to apply for a provisional order for the supply of electricity in the parish, and asking for the Vestry's support to obtain the same. It was resolved to refer the matter to committee.

Strand District Board of Works.—At the meeting of the Strand District Board of Works last week, intended applications to supply electric lighting in that district were received from the Metropolitan Electric Supply Company, London Electric Supply Corporation, House-to-House Electric Light Supply Company, Electrical Power Storage Company, and the Westminster Electric Supply Corporation, and referred to the Lighting Committee.

The Battle at Suakin.—The first telegram announcing the victory at Suakin, yesterday morning, was received in London, over the Eastern Telegraph Company's lines, only twenty minutes after the conclusion of the battle, while the second telegram, giving details, received shortly after 7 a.m., occupied thirty minutes in transit. The first message was handed in at 8.30 a.m. Suakin time, which is about two hours and a-quarter in advance of English time.

The Royal Institution.—The list of probable arrangements for the Friday evening meetings at the Royal Institution contains several events of more than usual interest to electricians. On Friday, February 8th, Sir William Thomson has a Paper on "Electrostatic Measurement," and a week later Prof. Rücker will read a Paper on "Electrical Stress." Finally, on March 8th, Dr. Oliver Lodge will have something further to say on "The Discharge of a Leyden Jar."

Okehampton.—The public supply of electricity upon a very limited scale is about to be undertaken at Okehampton by Mr. Henry Geen. Water-power is available to the extent of about 125 incandescents—the candle-power of the lamps has not been given us—and since gas costs 5s. 10d. per thousand in Okehampton the economic conditions are evidently favourable. Several houses in the town are now being wired, and arrangements are being made to lay the wires underground.

Contract for an Electric Launch.—Mr. James Adam, boat-builder, Cove Yard, Gournock, has received an order for an electric launch, to be built from the designs of Mr. G. L. Watson. Her dimensions are as follows:—Length, 50ft.; breadth, 7ft.; and depth, 3ft. 6in. She is to be built of the finest oak, and to have elm and cedar plankings. The modelling of the launch shows a cutwater bow and elliptic stern, with a house amidships. She is to be propelled by electric power, and is to be built without beams.

The City and Guilds of London Technical Institute.—On Wednesday evening the prizes and certificates gained by the successful students attending the schools, in connection with the City and Guilds of London Institute for the Advancement of Technical Education, were distributed at Fishmongers' Hall by Sir Lyon Playfair, M.P. In the course of his speech Sir Lyon Playfair said "he considered that the country owed a great debt of gratitude to the City and Guilds Institute, which had set a noble example to the whole kingdom."

St. George's (Hanover-square).—A meeting of the St. George's (Hanover-square) Committee of Works was held last week. Some discussion was raised upon an application for permission to lay a gas main in one of the parish footways, but Mr. William Adkins strongly objected to permission being given, as he thought that footways generally should be entirely reserved for the cables and electric lighting companies. Permission was given for the main to be laid in the roadway only.

Breakdown of the Fredericia-Calais Cable.—The submarine cable running from Calais to Fredericia (Denmark) has been interrupted since the beginning of the month, and telegrams to the North are being sent *vid* Berlin; the interruption has occurred near the middle of the cable. This cable, which belongs to the Great Northern Telegraph Company, was laid in

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1873, and is some 380 miles long; it connects France with Denmark, Scandinavia, and Russia, and thence with China.

Extension of Telegraphic Service.—The Postal Telegraphic Authorities are making arrangements for an important extension of the telegraphic communication between Glasgow and the north-west of England. From Glasgow the new line of wires will be carried along the Carlisle-road until Beattock, in Dumfriesshire, is reached. The route will then be through Central Annandale to Lochmaben, thence by Dalton to Annan, and across the Solway Firth to England. Several places at present without telegraphic communication will be accommodated.

Central Station Lighting at Derby.—We learn that Messrs. John Davis and Son, of Derby, who some time ago added electric lighting to their regular business of mining engineers, are now engaged in laying down a small central station lighting plant at their works, from which a part of the adjacent district will be lit. The plant first installed will have a capacity of 500 lamps, and will include a storage battery. This firm has also in hand some important orders for electric pumping and hauling plants for mining work, including an order for a gold mine in the Transvaal.

The Electric Light in the Royal Navy.—The Admiralty have decided to provide complete electric lighting installations on board the following war-ships:—The "Nile," "Hero," "Agamemnon," "Colossus," "Conqueror," "Shannon," "Forth," "Champion," "Basilisk," "Beagle," "Redbreast," "Redpole," "Magpie," "Goldfinch," "Lapwing," "Ringdove," "Widgeon," "Thrush," "Kingfisher," and "Sparrow." A contract for the supply of the plant has been entered into with Messrs. Willans and Robinson, at a total cost of £11,095. Three sets are to be supplied to the "Nile," two each to the "Agamemnon" and "Forth," and a single set to each of the other vessels.

"Our Christmas Annual."—We gladly notice this Christmas annual (Woolwich: F. J. Cattermole; London: Simpkin, Marshall and Co.), partly because of the charitable object with which it is published, but chiefly, perhaps, because many of the contributions are from the pens of well-known telegraph men. The proceeds of the sale are distributed amongst deserving cases of poverty and distress. The lady who undertakes the double task of editing the Annual and superintending the charity asks that the literary shortcomings may be pardoned; but, in reality, the stories are quite up to the average of this class of literature, and in some instances superior.

Ipswich.—At a special meeting of the Ipswich Town Council, held last week, it was decided to grant permission to Messrs. Lawrence, Paris and Scott to erect overhead wires for electric lighting purposes, such permission to extend over a period of twelve months only, in order to give the company time to make application to the Board of Trade for a provisional order, and to enable them meanwhile to proceed with the undertaking. Owing to the necessary period of one month not having expired since notice was received of the intention of the company to apply for a license or provisional order, the assent of the Council to the application could not then be given. A special meeting for this purpose will be held on January 9th.

Electric Lighting in the Inner Temple.—A petition to the treasurer and benchers of the Inner Temple is being extensively signed by the members of that Inn against the works at present in progress, in the Inner Temple Gardens, in connection with the installation of the electric light in the Inner Temple. The petitioners point out, among other things, that the erection of the engines, dynamos, and works in the Inner Temple Gardens will not only seriously depreciate the value of the chambers in the vicinity, but will constitute a permanent eyesore and disfigurement to the gardens. The petitioners, therefore, pray that if the extension of the electric light in the Inner Temple cannot be carried out except at such a sacrifice, the scheme be forthwith abandoned.

Leamington.—The Leamington correspondent of the *Birmingham Daily Gazette* says:—"Very little doubt is now entertained that Messrs. Chamberlain and Hookham's experiments with the lighting of the streets of Leamington by electricity will come to an end next year. The present contract price for the supply of electricity to the specified area is £400 a year. The amount previously paid to the gas company for lighting the two thoroughfares was less than £200 a year. In view of the disproportionate increase in the cost of electricity as compared with gas it is believed that at their meeting on the 14th prox. the Leamington Corporation will give the required twelve months' notice to determine the supply of the current to the public lamps.

Metropolitan Board of Works.—At the Metropolitan Board of Works, on Friday last, a letter was received from Messrs. Latimer Clark, Muirhead and Co., on behalf of the St. James and Pall-mall Electric Light Company (Limited), giving notice of their proposal to lay electric light mains in Duke-street, St. James's, and certain other places in that neighbourhood. A letter was received also from Lord Crawford, on behalf of the London Electric Supply Corporation (Limited), asking permission to lay a main for conveying electricity through part of the Victoria Embankment Garden, and stating that Her Majesty's Office of Works had already granted the company permission to lay mains through the War Office Garden and along the St. James's and Green Parks. The subject was referred to the Works and General Purposes Committee.

St. Martin-in-the-Fields Vestry.—At their last meeting the Vestry proceeded to consider a motion to give consent, under rule 8 of the rules made by the Board of Trade with respect to applications for licenses and provisional orders under the Electric Lighting Acts of 1882 and 1888, to the granting of a license by the Board of Trade authorising the Metropolitan Electric Supply Company (Limited), to construct and maintain electric lines and works, and to supply electricity within the parish. The clerk (Mr. G. W. Murnane) said the Vestry gave their assent to a Bill last June, and he asked for leave to arrange with the solicitors to the Bill. They had introduced several interlineations into the arrangements proposed; some of them were of a technical nature, but he could not advise the Vestry to adopt them. He had seen the solicitors on the question, and they had agreed to his terms. He had conferred with Mr. Harry Wilkins, the Vestry Clerk of St. James's, Westminster, and they worked in concert. He considered the Vestry might give consent. This was done.

The Lighting of the City.—At the last meeting of the Commission of Sewers Mr. Treloar asked when they were to receive the report of the Streets Committee as to electric lighting, and why it had been delayed. Mr. Bridgman replied that the committee had done all they possibly could in the matter. They had decided upon the principle upon which the conditions for tendering would be based, and the matter was now with the officers. The engineer had communicated to him, through Mr. Preece, the electrician consulted, his views, which had been sent to the solicitor, who had considered the documents and returned them. The engineer was putting the matter into proper shape, and as soon as this was done the committee would be glad to discuss it. The committee had determined that the matter should be settled before they went out of office. Mr. Rose-Innes asked whether it would be open to private persons or companies to tender. Mr. Bridgman replied that it would be publicly advertised, and the conditions would be sent to those who applied to tender.

Westminster.—At a meeting of the St. Margaret's and St. John's (Westminster) Vestry last week the Parliamentary Committee reported that, in accordance with the instructions of the Vestry, "to fully inquire into the whole question of electric lighting," they, as a commencement of the inquiry, had requested information on the subject from several metropolitan local authorities. They had had under consideration notices of intended applications for provisional orders to produce and supply electricity within these parishes by the Metropolitan Electric Supply Company (Limited), the Westminster Electric Lighting Company, and the London Electric Supply Coporation, and recommended that they should be opposed. The committee also reported that they had empowered the solicitor to the Vestry (Mr. Warrington Rogers) to instruct the Parliamentary agents to draw and lodge formal objections against the licenses now before the Board of Trade, "on the ground that the Vestry should retain the control of the lighting of the parish

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in its own hands." The report and recommendation were unanimously agreed to.

Opposition to the Pall Mall Electric Light Company's Scheme.—Mr. E. C. Keevil, who, at the last ordinary meeting of the St. James's Vestry, complained of the huge smoke shaft to be erected within 200 yards of Marlborough House, the Carlton Club, and St. James's-square, at the central station of the Pall Mall Electric Light Company in Mason's-yard, has issued a circular to the ratepayers and inhabitants of the Pall Mall Ward, in the hope of convening a public meeting for the purpose of obtaining an injunction to remedy the contemplated serious nuisance. He points out that the vibration of the machinery, which will be of a very massive character, together with the smoke of the works, going on day and night, will be so great a nuisance that many houses in the immediate neighbourhood will become vacant, as was the case in Paddington. Such an installation in their very midst was calculated to seriously injure the interests of clubs, hotels, and private residents. We may, however, add that Mr. Keevil must not take the Paddington installation as any criterion of what an electric light station need or ought to be.

Electric Lighting in the Houses of Parliament.—On Monday last Mr. Howorth asked the First Commissioner of Works whether, during the ensuing recess, he could see his way to make such an extension of the electric lighting arrangements in the House as would check further injury to the stonework in the corridors and staircase leading from the Star Court to the Commons lobby, and whether it would be possible to carry the electric light into the different rooms connected with the Reporters' Gallery.—Mr. Plunket: I quite agree in the desirability of the objects sought by my hon. friend, and I have under consideration a scheme for extending the electric lighting of this building, which would include and go somewhat further than the suggestion of my hon. friend; but the cost of the installation would be considerable, and I must obtain the opinion of the Treasury upon its financial aspect. I fear it would not in any case be possible to complete the arrangements earlier than Easter.—Sir J. Swinburne inquired whether the right hon. gentleman was aware that the electric light had been so dim in the library that members had had to use candles as auxiliaries.—Mr. Plunket thought it must be very seldom that candles were used. He had never seen them in the library.

The Electric Light in Land Warfare.—On Saturday night some interesting experiments were made on Hampstead Heath for the purpose of testing the capacity of small electric hand-lamps in searching for the wounded men left after a battle, and thus more rapidly than hitherto bringing the sufferers within the reach of surgical aid. The experiments were made by the officers and men of the London Division of the Volunteer Medical Staff Corps, an organisation which already consists of four efficient companies, largely composed of medical students, and for which a fifth company is now in process of formation. The corps, under Surgeon-Commandant Norton, accompanied by ambulance waggons, and provided with stretchers, halted upon one of the Heath roads at a time when the thick mist still hung heavily upon the lower grounds; and having established a field hospital in a rather dreary-looking spot, poorly sheltered by bare trees, sent out its searching stretcher parties to pick up the bandsmen who had been distributed over the open ground at some distance off, to simulate the wounded left from a fight during the daylight. By the aid of the lamps thus brought into such use for the first time, the men sought were found with comparative rapidity, the lights being sufficient also to enable the trained ambulance men to apply preliminary bandaging upon the spot, and before loading the stretchers, which by other lights at the waggons were guided back to the road. There the men were carefully placed in the vehicles and conveyed to the field hospital, where the examining surgeons found very little to correct in the treatment adopted under such disadvantageous circumstances. The results achieved indicate sufficiently well, says the *Daily News*, that the electric light thus used would be of immense value, and tend greatly to reduce the suffering of men left upon the field at the close of a fight.

Kensington Vestry.—At the last meeting of this Vestry the Special Committee for Electric Lighting reported that they had considered the letter from the Chelsea Electricity Supply Company (Limited), asking for a way-leave for an electric main in Ovington-gardens, Brompton-road, for the purpose of connecting certain mains of the company, and reporting that the committee are not prepared to advise the Vestry to accede to such application, and the Board of Trade have stated that they do not propose to entertain any further applications from electric lighting companies for licenses in respect of such areas in the metropolis. A deputation consisting of Mr. Alexander S. Hill, Q.C., M.P., Sir Theodore C. Hope, and Mr. Charles Fish attended the committee on behalf of inhabitants in the vicinity of Queen's-gate, urging that permission should be granted to the Kensington Court Company for the extension of their mains in this direction, and referring to the inconvenience by the delay in granting licenses for the supply. The committee recommended that in the event of application being made by the Kensington Court Electric Lighting Company (Limited) to the Board of Trade for a license under the Electric Lighting Act, 1882, to lay down wires for the supply of electricity in streets in the vicinity of Queen's-gate, the Vestry do give their consent to such application so far as regards the area in question, subject, however, to conditions being agreed to by the company similar to those contained in the license above referred to, and provided that, in the event of any general system being hereafter adopted by the Vestry for the laying of mains, &c., the company undertake to change the mains now proposed to be laid in such manner as to conform to and generally to be subject to such future system. All the mains, &c., now proposed to be laid down, to be laid in such part of the roadway or footway, and generally on such conditions and in such mode as may be approved by the Vestry's surveyor.—Mr. Holmes, who thought that if the demands of the deputation were acceded to, it would create a monopoly, moved that the matter be referred back, which was finally carried.

The Late Fire at Messrs. Willans and Robinson's.—The managers of these works, whose machine shops at Thames Ditton were entirely destroyed by fire lately, with all the patterns and templates, have lost no time, says *Industries*, in reorganising the business. With a few exceptions the orders in hand will not be delayed more than two months, and the company is already booking orders largely for delivery early in the summer, when it is hoped that all the engines on order at the time of the fire—upwards of one hundred—will have been finished. That such energetic steps have been taken to repair the disaster is a matter of some importance to the electric lighting industry, which appeared to be threatened with a vexatious check at a busy time. The large engines for the town lighting station of the Bradford Corporation, of above 150 horse-power each, which were ready to receive the dynamos, were unfortunately burnt, so were two 70 horse-power engines, forming a repeat order (through Messrs. Mather and Platt) for the Fine Art Galleries at Leeds. A similar engine, ready to receive a Siemens dynamo, for the Liverpool Electric Supply Company, was burnt, but fortunately a larger set for the same company, giving 1,500 lights, had been sent away shortly before the fire. Two engines for Messrs. L. Clark, Muirhead and Co., for the Pall Mall Electric Light Company, of 210 indicated horse-power each, were burnt, but some other Willans engines for the same station will be finished in time to prevent delay in opening this station. Some 70 horse-power engines, for the Kensington Court Company, were in the erecting shop and escaped; but three engines of 170 horse-power each, making to the order of Messrs. Siemens for an important installation in London, were less fortunate. However, in all cases satisfactory arrangements have been made to fill the orders with the least possible delay. A great number of engines are in hand for the Admiralty, chiefly for lighting the newer classes of vessels, including nearly thirty engines of the size before referred to as of 70 horse-power, and about 40 of smaller sizes. All these are, of course, for direct driving. Amongst them are four large engines for the Royal yachts "Victoria and Albert" and "Osborne," to work at exceedingly low steam pressure. These engines are required to replace other high-speed engines with which the yachts are already fitted.

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LIGHTNING CONDUCTORS.—VI.

BY DR. OLIVER LODGE.

(Continued from page 162.)

On the Value of μ which makes Calculation and Experiment best agree.

37. It is an important matter to know what is the true value of the magnetic permeability of iron applicable to these very rapid alternations, and we will see if the last article can help us to an answer.

First, it will be instructive to calculate out the whole circumstances of the experiment of § 25, assuming the value of μ to be 400 for iron wire under the circumstances. The following table (Table I.) shows the result, and it can be compared with the table in Article IV., which gave the results for $\mu = 100$ and $\mu = 2{,}500$.

The meaning of the symbols heading the columns has been already explained, but it may be well to recapitulate. P is the total impedance of a conductor, p is the inertia part, and R the resistance or throttling part of it; n is 2π times the number of times the current alternates in a second; and b is a constant such that $R = b\sqrt{n}$. Its value is $\sqrt{(\frac{1}{2} l \mu r)}$ where l is the conductor, r its ordinary resistance, and μ its magnetic permeability.

In one of the rows of the table the expressions by which these things are calculated, or references to the equation or section where such expressions can be found, are, for convenience, added.

The No. 19 conductor is given a part of the table to itself because it formed a permanent part of the circuit; the other four conductors are alternative-paths, and were successively placed in series with the No. 19 conductor. V being the potential acting in the whole circuit, V_0 is the potential acting in the alternative-path portion. The last column of the table exhibits the ratio of these potentials as obtained by direct measurement of the A and B sparks, for the purpose of comparison with the calculated or theoretical values. I may mention that, by help of Art. V., the values of m and n are now calculated more exactly than they were in Art. IV.

38. Plainly the agreement between theory and experiment is, for this value of μ, not very good. It was much better for $\mu = 100$ if the damping were neglected; but it can hardly be legitimate to neglect the damping.

The agreement was very good with $\mu = 2{,}500$ for the three cases which could be calculated out (*see* table in Art. IV., p. 129). The fourth case was not then worked out, but we ought now to be able to do it by help of Article V. The result is shown in Table II.

Thus the agreement between theory and observation is very close for this fourth case also, if μ be taken as 2,500. This set of experiments seems, therefore, to indicate 2,500 as a probable value for μ. It is surprisingly large.

39. To bring out the effect of different values of μ more clearly I append here a table (Table III.) showing the calculated ratio of potentials, available for the A and the B spark respectively, with different values of μ, namely, with $\mu = 1$, $\mu = 100$, $\mu = 400$, $\mu = 2{,}500$. This table gives not only the theoretical ratio of potential but also its undamped value in each case, and thus clearly exhibits the effect of damping.

There is no doubt but that the largest value of μ gives the best agreement. We must not put too much confidence in the indication of this one set of experiments, but we will remember the hint and proceed to discuss a few earlier observations, recorded before § 25.

We may, however, just notice before leaving that this last table serves to illustrate in a general way the truth of what we reckoned in § 36, viz., that if $\frac{P_0}{p+p_0}$ was less than $\frac{2}{\pi}$ (or ·636), an increase in μ diminishes the ratio $\frac{V}{V_0}$; whereas so soon

TABLE I.—*Calculated on the Assumption that μ for Iron is 400.*

Conductor.	L	b	n	R	p	P					
			Millions.	Ohms.	Ohms.	Ohms.					
No. 19 Copper..	67,000	$2{\cdot}3 \times 10^6$	1·63 1·50 1·32	2·94 2·82 2·65	109 101 88·5	109 101 88·5					
	(§19) L_0	$\sqrt{(\frac{1}{2}\mu l r)}$ a	(16) n	$(a\sqrt{n})$ R_0	$(n L_0)$ p_0	$\sqrt{(p_0^2 + R_0^2)}$ P_0	$p+p_0$	(18) $\frac{m}{n}$	$e^{-\frac{\pi m}{2n}}$	(11) Calculated. $\frac{V}{V_0}$	Observed. $\frac{V}{V_0}$
			Millions per second.	Ohms.	Ohms.	Ohms.	Ohms.				
No. 1 Copper..	39,000	$·18 \times 10^6$	1·63	·23	63·7	63·7	173	·00924	·986	·362	·346
No. 1 Iron ...	39,000	6·9	1·63	8·81	63·7	64·3	173	·0336	·948	·351	·366
No. 18 Iron ...	55,000	46	1·50	56·4	82·5	99·9	183·5	·160	·779	·423	·490
No. 27 Iron ..	63,000	142	1·32	163	83·5	183·1	172	·456	·489	·520	·660

TABLE II.—*Case of the No. 27 Iron Wire Worked out for $\mu = 2{,}500$.*

Conductor.	a	n	R_0	p_0	P_0	$p+p_0$	$\frac{P_0}{p+p_0}$	$\frac{m}{n}$	$e^{-\frac{\pi m}{2n}}$	Calculated. $\frac{V}{V_0}$	Observed. $\frac{V}{V_0}$
	Millions.	Million.	Ohms.	Ohms.	Ohms.	Ohms.					
No. 27 Iron ...	354	·52	256	32·6	258·1	67·4	3·83	1·14	·169	·65	·66

TABLE III.

Conductor.	$\mu = 1$.		$\mu = 100$.		$\mu = 400$.		$\mu = 2{,}500$.		Observed. $\frac{V}{V_0}$
	$\frac{P_0}{p+p_0}$	Calculated. $\frac{V}{V_0}$	$\frac{P_0}{p+p_0}$	Calculated. $\frac{V}{V_0}$	$\frac{P_0}{p+p_0}$	Calculated. $\frac{V}{V_0}$	$\frac{P_0}{p+p_0}$	Calculated. $\frac{V}{V_0}$	
No. 1 Copper	·367	·367	·367	·363	·367	·362	·367	·360	·346
No. 1 Iron	·367	·367	·367	·354	·371	·351	·389	·347	·366
No. 18 Iron	·447	·445	·473	·416	·544	·423	·91	·485	·490
No. 27 Iron	·483	·472	·640	·461	1·06	·520	3·83	·650	·660

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as $\frac{P_0}{p+p_0}$ gets up to (or apparently near) $\frac{2}{\pi}$, an increase in μ makes $\frac{V}{V_0}$ increase.

Application of Theory to Previously Recorded Experiments

40. Although in the experiments recorded before § 25 we had not quite complete data for applying theory, inasmuch as the particulars of the jar part of the circuit were not specially noted, yet we can try the estimate of 50 metres which we have already made for its self-induction (§ 19), and see whether anything can be done. This is the more desirable because the experiments comparing a round wire, a ribbon of foil, and a strip of gauze come in this portion of the record (*see* §§ 22 and 23). It is probable that for most of these cases the first approximation alone will serve fairly well, since the resistance of the whole circuit was but small.

Wire v. Ribbon.

Referring back to Art. III., therefore, and using the dimension of wire and foil recorded in § 22, I calculate the self-induction of the piece of No. 12 wire by equation (7) as being 26 metres; which becomes 25 metres if the current keeps to the surface.

For the foil, if the current were distributed uniformly all through it, the self-induction would be

$$L = 4\pi r\left(\log \frac{8r}{\cdot 2656\, b} - 2\right) = 436 \times 3\cdot 10 = 13\cdot 5 \text{ metres};$$

where b is its breadth (6·4 centimetres), its thickness being very small. If the current keeps to the surface, L is a trifle less than this, and if it distributes itself unequally, so as to make L as small as possible, as in practice it will, there will be a further reduction; but its amount I do not quite know how to reckon. So I shall take the self-induction as 25 metres for the wire, and 13 metres for the foil.

Hence, using them as alternative paths, and applying the first approximation, with L assumed 50 metres, we should have:—

$$\frac{V}{V_0} = \frac{L_0}{L+L_0} = \frac{25}{75} \text{ for the wire,}$$

and

$$\frac{13}{63} \text{ for the foil.}$$

Comparing these and similarly made calculations with the observations recorded in §§ 23 and 24, as made with two-gallon jars and various alternative paths, we have the following table, comparing theory and experiment:—

Alternative Path.	$\frac{L_0}{L+L_0}$.	Theoretical B spark between flat plates.	Calculated Length of B spark between knobs used.	Observed Length of B spark.
Circle of No. 12 wire	·333	·500	·53	·55
Ribbon of copper foil	·206	·310	·33	·27
Ribbon of copper gauze ...	—	—	—	·27
Long No. 19 copper wire .	·920	1·38	1·62	1·65
No. 27 iron wire	·925	1·39	1·65	1·68
No. 1 copper wire.....	·886	1·33	1·54	1·63
No. 27 iron wire	·925	1·39	1·65	1·63
No. 18 iron wire	·921	1·38	1·62	1·68
No. 19 copper wire.....	·920	1·38	1·62	1·68

This is not a complete account of the matter, because the experiments recorded in § 24 as having been made with pint jars are omitted. The first approximation by itself shews no reason why the capacity of the jars used should matter; but, experimentally, it did matter somewhat.

The calculated spark-length for the copper foil is too great; probably I have not allowed enough for the freedom of distribution of current inside a ribbon. The real self-induction would be less than what I have reckoned it. The slight discrepancy of the No. 1 copper I see no reason for. The self-induction of the strip of gauze I have not yet reckoned.

Earlier Experiments reduced by help of § 21.—Again, going further back still in the record of experiments to §§ 16 and 17, and reducing the spark-lengths there given to centimetres between flat plates, we have A = 1·87 centimetre, and for B the following numbers:—

Alternative path.	Observed B spark reduced to flat plates.
No. 1 copper	1·66 cm.
„ 27 iron	1·51 „
„ 1 „	1·53 „
„ 19 copper	1·62 „
„ 18 iron	1·53 „
Two gutta-percha leads in concurrent series	1·80 „
„ „ „ in opposing series	1·48 „
„ „ „ in parallel	1·48 „
One lead only	1·48 „
One lead, with the other one closed	1·41 „

Applying the first approximation theory to the No. 1 copper lead, and taking L as 50 metres, we get as the theoretical B spark, for this case, 1·65 centimetre; which agrees with observation. The other leads seem to require the second approximation to bring out their slight differences.

We will now proceed with the record of further experiment.

(To be continued.)

MR. MACKIE'S REPORT ON THE PADDINGTON ELECTRIC LIGHTING SCHEME.

To Frank Dethridge, Esq., Paddington Vestry.

Sir: I herewith enclose for the guidance of your Vestry estimates of cost for electric lighting of the Borough of Paddington, from a central station at the dust yard.

I have given, first, an estimate (A), for lighting by continuous current with underground copper leads for a unit installation of 2,000 16 candle-power incandescent lights; and another (B), for the like unit of 2,000 incandescent lights under the alternating system.

Every installation of 2,000 lights will be remunerative, and, therefore, the central station can comprise as many such units as may be desired to start upon, or be added from time to time.

I also add a third estimate (C), which deals with the portion of the dust yard which is at once available without encroaching on any of the buildings or plant required for the dust work.

This portion (C) I suggest should be used, in the first instance, as a pioneer station, and should form a nucleus at the present time; and in the future, when units of the central station shall have been added, it should still be retained for the same purpose, and for which it was designed, viz., to seek for and supply customers in all directions, and with both incandescents and arc lights. To this end this station (C) has been designed to receive three continuous-current dynamos for 1,000 incandescent lamps each, two continuous-current dynamos for 50 arc lights each, two alternating-current dynamos for 500 incandescent lamps each.

This would be a considerable station in itself and remunerative. The total of incandescent lights would be 4,000, and the number of arc lights 100, for streets and other purposes.

It is to be understood that the reasons for advising this (C) station to be first adopted are:—1. That the site exists and can be appropriated to the purpose; 2. That this (C) station can supply lights to any part of the Borough, however distant, and to isolated customers or small groups of customers; 3. That the outlay will be the least upon which a central station can be based.

The respective costs of the A and B units are:—*a*. Continuous-current system, with copper leads, as marked on map, the cost, including machinery and plant, would be £10,425. 10s. *b*. The alternating-current system, with light overhead wires, would be for machinery and plant £7,019. 12s. 6d., showing a difference of £3,405. 17s. 6d.

In judging of the comparative desirability of the continuous-current system it should be borne in mind, first, that the current is never dangerous; second, that the service is underground; third, that storage batteries can be charged by it; and, fourth, consequently there is an additional very important safeguard against a breakdown, as (fifth) the accumulators can always supply current night and day for a limited time, and therefore (sixth) the engines need only be run on the lighting after dusk or during fogs; or if (seventh) the engines are employed in the daytime in charging batteries of accumulators, an additional number of incandescent lights can be run at night.

The cost of working and maintenance of the (A) continuous-current unit is £4,022. 14s. 3d., of the (B) alternating unit £4,403. 3s. Transforming the total current into cost of 16 candle-

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power lamps, we have price per hour 0·2207 of a penny, and of the alternating current 0·2416 of a penny. Or in Board of Trade units "1,000 watts" continuous current 3·7519; alternating current 4·1072 of a penny. The price paid by consumers in both cases is 7¼d. Therefore, 2,000 lamps of 16 candle-power, running 2,186 hours, gives 263,320 Board of Trade units at 7¼d., yielding an income of £7,924. 5s. per annum, less expenses of working £4,022. 14s. 3d., leaving a balance of £3,901. 10s. 9d.; or a dividend of about 37 per cent. on the capital outlay.

The objections to the alternating system are:—1. That the current is of such high tension as to be unsafe for use in edifices, or otherwise, without the use of transformers to reduce its tension, before entering the house, to safe limits. 2. The engines must be run night and day, as (3) accumulators cannot be charged by alternating currents, and consequently there is (4) not that safeguard against breakdowns. (5) That arc lights cannot be so well run on alternating currents as on continuous currents, and each arc in street lighting and each group in a building would require a transformer.

The advantage of the alternating-current system is that the current can be carried for any distance by very small and comparatively inexpensive wires. Taking the income as before at £7,924. 5s., and the alternating-current expenses at £4,403. 3s., the balance would be £3,521. 2s., or a dividend of 50 per cent. on the capital outlay. The cost of the proposed C station would be £21,170. The income would be from the 4,000 lamps at 7¼d. per unit £15,583, and 100 arcs at £27 per year £2,700, or a total of £18,283. The expenses would be £10,027. 5s., giving a net profit of £8,255. 15s. on a capital of £21,170, or a dividend of nearly 39 per cent.

In regard to the map accompanying the report, I would observe that the least costly but most effective route for the main electric current leads (continuous current laid underground) has been mapped out, and that this system taps the main thoroughfare of Edgware-road, and the great mass of mansions lying between the Central Station at the dust yard and Hyde Park. This district is well calculated for securing a number of customers, and, consequently, of being a profitable district.

I would, however, observe that the intervention of the Great Western Railway's extensive property between the dust yard Central Station and Westbourne-grove would cause an expenditure of some thousands of pounds for copper leads, if served by continuous current of low tension. But this important district can be very cheaply reached by alternating current and overhead wires, with high-tension current, reducible at customers' residences or shops by transformers. The suggested line of alternate-current mains is shown on the map by a yellow line and dot. I may also remark that the Pioneer Central Station (C) system can be materially strengthened by three sets of storage batteries at, say, the spots marked blue on the map.

It might be well to generally remark here that, as the (C) Pioneer Central Station is designed, a commencement of the permanent underground system is made; and that beyond this provision is otherwise made for supplying any person or any district that may desire it with electric light, the actual cost of length of light-wire mains in each particular case being the only item which cannot be stated in advance, depending, as it does, on the particular circumstances of each case.

No mention has been made in this report of the use of electricity for motive power. The suggested (C) station, however, would be capable of supplying power in the daytime if required, and profit would accrue from this source.

In regard to the powers to be taken by the Vestry under the Act those powers would extend to the whole borough, and all the inhabitants would be entitled to equitable treatment. It would not be needful for the Vestry to incur the outlay and responsibility of extending the electric lighting over the whole area at once. They must, however, state in the provisional order the extent of area they will light in the first year, and how much extension of area they will light in the following three years. Beyond this the extension is purely optional, the Vestry granting on applications from individuals or districts, or refusing if they choose to do, the applicants having power of appealing against injustice to the Board of Trade. If the Vestry wished to restrict their power to a minimum, the work to be done in the *first* year might be the erection of *part* of the (C) station, say the erection of two boilers, two engines, and two alternating dynamos for 1,000 lamps. The work to be done in the following three years might be a portion of the continuous-current system, and of the mains laid down on the map, say the laying of the leads to the South Wharf-road. The remainder of the electric work would be done on application by individuals or districts, and the concurrence of the Vestry therewith.

The Vestry having obtained powers for the whole borough could at any time advance the general works beyond the legal liability incurred in the grant of the provisional order.

Finally, I would say that the estimates given are, in my judgment, ample for covering any probable expenditure, and that if specifications shall be directed by the Vestry at any time hereafter to be prepared, the tenders sent in should be for less amounts. The estimates are all based on the supply of current only by the Vestry; and it is distinctly advised that house and internal fittings be left entirely with the customers, except that in every case the Vestry shall have the approval of the same as being proper and safe for the service.

S. J. Mackie.

A.—CONTINUOUS CURRENT UNIT.

Engines.

Three multitubular boilers indicating 300 horse-power	£1,400	0	0
Fixing same and foundations	85	0	0
Two high-speed engines, £460 each	920	0	0
Add 10 per cent. for increased speed	92	0	0
Hauling same into position	30	0	0
Foundations for ditto, and holding-down bolts	90	0	0
Steam connections and valves	120	0	0
	£2,737	0	0

Continuous Current.

Copper leads	£3,444	0	0
Cart, ladders and lines	22	0	0
Contingencies	100	0	0
Superintendence	50	0	0
Taking up footway and replacing	875	0	0
Brick troughs, &c.	400	0	0
Two continuous-current machines	800	0	0
Bed plates	50	0	0
Foundations for same	16	10	0
Hauling machines into position, &c.	20	0	0
Two belts to machines	48	0	0
Two belts from engines	12	0	0
Iron traps—30 at 8s.	12	0	0
Insulators and stand	17	0	0
Labour laying copper strip	45	0	0
	£5,948	10	0
Accumulators	900	0	0
80 meters	840	0	0

SUMMARY OF YEARLY EXPENDITURE FOR CONTINUOUS CURRENT.

2,000 lights for 2,186 hours per annum, which time is from sundown to midnight = 732 tons coal at 15s.				£549	0	0
Water, 1,780,800 gallons, at 6d. per 1,000				44	10	0
Rent of meter				1	0	0
Oil and waste				75	0	0
Labour				845	0	0
Depreciation:—						
10 per cent. on engines and boilers			£253	0	0	
1 „	copper leads		101	0	0	
10 „	footways, troughs, machines, &c.		215	0	0	
5 „	foundations		0	16	3	
15 „	belts		14	8	0	
12 „	accumulators		108	0	0	
Interest on capital 5 per cent.			865	18	0*	
„ „	for meters		50	0	0	
					1,608	4 3
Management			500	0	0	
Offices and collector's salary			400	0	0	
					900	0 0
					£4,022	14 3

= *d.* 482·725 per lamp per annum.
= *d.* ·2208 „ „ hour.
Taking 2,186 hours per annum, from sundown to midnight.

B.—ALTERNATING-CURRENT UNIT.

Engines.

Three multitubular boilers, indicating 300 horse power	£1,400	0	0
Fixing same and foundations	85	0	0
Two high-speed engines, £460 each	920	0	0
Add 10 per cent. for increased speed	92	0	0
Hauling same into position	30	0	0
Foundations for ditto, and holding down bolts	90	0	0
Steam connections and valves	120	0	0
	£2,737	0	0

Alternating Current.

Thirty posts and fittings, at £4. 18s. 4d. each	£147	10	0
2,500 yards steel cable	9	7	6
Clips for ditto	8	15	0
5,000 yards triple insulated cable, £230 per mile	610	0	0
Lineman's tools, two sets	5	0	0
Cart, ladders and lines	22	0	0
Contingencies	100	0	0
Superintendence	50	0	0
Six men's labour, erecting posts and cables	62	0	0
Carried forward	£1,014	12	6

* [This item appears to be considerably overstated; 5 per cent. on £10,425 is only £508.—Ed. *E.*]

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Brought forward	£1,014	12	6
Two 75,000-watt alternating machines and exciters	1,300	0	0
Two foundations and bed plates	60	0	0
Labour, hauling machines in position	20	0	0
Two best belts	43	0	0
Transformers, taking an average of 2,000 lights divided into 80 transformers of 25 lights each	1,000	0	0
Meters, taking same average as in transformers	840	0	0
	£4,282	12	6

YEARLY EXPENDITURE FOR ALTERNATING CURRENT.

2,000 lights for 2,186 hours per annum, which time is from sundown to midnight, equals 732 tons coal at 15s.	£549	0	0
Water, 1,780,800 gallons at 6d. per 1,000	44	10	0
Rent of meter	1	0	0
Oil and waste	75	0	0
Labour	1,560	0	0
Depreciation on plant	722	14	0
Rent of posts	150	0	0
Interest on capital	400	19	0
„ „ meters	50	0	0
	3,503	3	0
Management £500 0 0			
Offices and collector's expenses 400 0 0			
	900	0	0
= *d.* 528·378 per lamp per annum. = *d.* ·2417 „ „ hour.	£4,403	3	0

C.—PIONEER CENTRAL STATION.

Plant consisting of—

Five high-speed engines.	Three continuous-current dynamos.
Two high-speed engines.	Two arc-lamp dynamos, 50 lamps each.
Two 500-light alternating dynamos.	One hundred arc lamps.
Two exciters for ditto.	Accumulators, &c., &c.
Four multitubular boilers.	

ENGINES AND BOILERS.

Four multitubular boilers, for 600 horse-power	£2,800	0	0
Fixing same	85	0	0
Five engines, £460 each	2,300	0	0
Add 10 per cent. for increased speed	230	0	0
Hauling same to positions	70	0	0
Foundations for ditto and holding down bolts	150	0	0
Steam connections and valves	240	0	0
Two high-speed engines, £200	400	0	0
Foundations for same	32	0	0
Belts „	24	0	0
	£6,331	0	0

CONTINUOUS-CURRENT PLANT FOR 3,000 LIGHTS.

Copper leads laid down as marked on map	£3,444	0	0
Cart, ladders, and lines	22	0	0
Contingencies	100	0	0
Superintendence	150	0	0
Taking up footway and relaying, 7s. per yard	1,848	10	0
Brick troughs, &c., 2s. per yard	528	0	0
Three continuous-current dynamos	1,200	0	0
Bed-plates	75	0	0
Foundations for same	24	15	0
Hauling machines in position	30	0	0
Seventy-five iron traps, 8s.	30	0	0
Insulators and stands	67	10	0
Labour laying copper strips	135	0	0
	£7,654	15	0
Accumulators	£900	0	0
120 meters	1,260	0	0

CAPITAL OUTLAY.

Engines and boilers	£6,331	0	0
Alternating current	2,904	15	0
Arc lights	2,119	10	0
Accumulators	900	0	0
Meters	1,260	0	0
Continuous current	7,654	15	0
	£21,170	0	0

ALTERNATING CURRENT

Thirty posts and fittings	£147	10	0
Steel cable	18	15	0
Clips for ditto	9	10	0
5,000 yards triple insulated cable	610	0	0
Lineman's tools	5	0	0
Cart, ladders and lines	22	0	0
Contingencies	100	0	0
Superintendence	50	0	0
Six men's labour	62	0	0
Two alternating machines for £500 each	1,000	0	0
Two foundations and bed-plates	60	0	0
Labour on machines	20	0	0
Transformers	800	0	0
	£2,904	15	0

ARC-LIGHT DYNAMOS, &c.

Two 50-light machines	£700	0	0
Two foundations and bed-plates	80	0	0
Two high-speed engines (*see* Engines).			
$\frac{7}{8}$ cable, say one mile	80	0	0
Thirty posts and fittings	147	10	0
Fixing same	62	0	0
Superintendence	50	0	0
100 arc lamps, £10	1,000	0	0
	£2,119	10	0

CENTRAL STATION OF 4,000 INCANDESCENT LAMPS AND 100 ARCS.

YEARLY EXPENDITURE for making an average run of 2,186 hours per annum with full load.

1,761 tons of coal, 15s. per ton	£1,320	15	0
Water	110	0	0
Rent of meter	5	0	0
Oil and waste	150	0	0
Labour	2,200	0	0
Depreciation on plant	2,461	0	0
Rent of posts	300	0	0
Interest on capital	1,230	10	0
Carbons for 100 lamps, 2,186 hours	950	0	0
Management £500 0 0			
Offices and collector's expenses 800 0 0			
	1,300	0	0
	£10,027	5	0

COST OF LAMPS PER ANNUM.

= *d.* 501·34
= *d.* ·229 per lamp per hour.

INCOME.

4,000 lamps at 7¼d. per unit	£15,583
100 arc lamps at £27 per year	2,700
	£18,283
Showing a net profit of	£8,255 0 0
on a capital of	21,170 0 0

or a dividend of 39 per cent. nearly.

London, 27, Chancery-lane, 17th September, 1888.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION II.—ELECTRO-MAGNETIC FIELDS.

(*Continued from page 140.*)

139.—*Electro-Magnetic Induction.*—We shall conclude this section with a consideration of electro-magnetic induction and magnetic permeability, both of which are closely allied to the foregoing subject of magnetisation, and in such constant use in descriptions of, and discussions on, electro-magnetic appliances as to make it important for the student to have a clear conception of their meanings. At the same time, consistently with making the subject intelligible, we shall dwell on it as briefly as possible.

At the outset, the relation which "magnetic induction" bears to "intensity of magnetisation" should be clearly understood. We may state this concisely by saying that intensity of magnetisation is proportional simply to the number of lines of force per unit area passing through the iron *due to its own acquired magnetism*, while magnetic induction is proportional to the number of lines per unit area passing through the iron, due to its own acquired magnetism, *plus those due to the magnetising field.* The latter is the more practically useful means of measurement, since, in practice, we necessarily concern ourselves with the *combined magnetic effect* of the magnetised iron and the electro-magnetic field causing its magnetisation. Recalling what was said in para. 133, it will be remembered that through the mass of any piece of iron which has been magnetised to a strength of pole equal to m C.-G.-S. units, and whose dimensions satisfy the condition of "endlessness," there are $4\pi m$ lines running from pole to pole (south to north). The condition of "endlessness" ensures the absence of any demagnetising lines (running from north to south, or in a contrary direction through the metal) which would make the actual number of lines through such a piece of magnetised iron less than $4\pi m$.

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Such being the case, we have in a piece of iron of a square centimetres (uniform) cross-section $\frac{4\pi m}{a}$ lines per square centimetre passing through its mass and *due to its own acquired magnetism*. Now, the intensity of magnetisation (I) is found by

$$I = \frac{m}{a},$$

putting which value in the above we find that

$4\pi I$ = lines per sq. cm. due to acquired magnetism;

and, therefore,

$$I = \text{lines per sq. cm. due to acquired magnetism} \times \frac{1}{4\pi}.$$

This proves the statement made above, that the intensity of magnetisation is proportional to the lines of force per square centimetre through the iron, due *alone* to the magnetism acquired. The same fact will have been noticed in the practical examples already detailed, in which the magnetising force of the coil was *subtracted* from the combined magnetic effect of the coil and core together before calculating

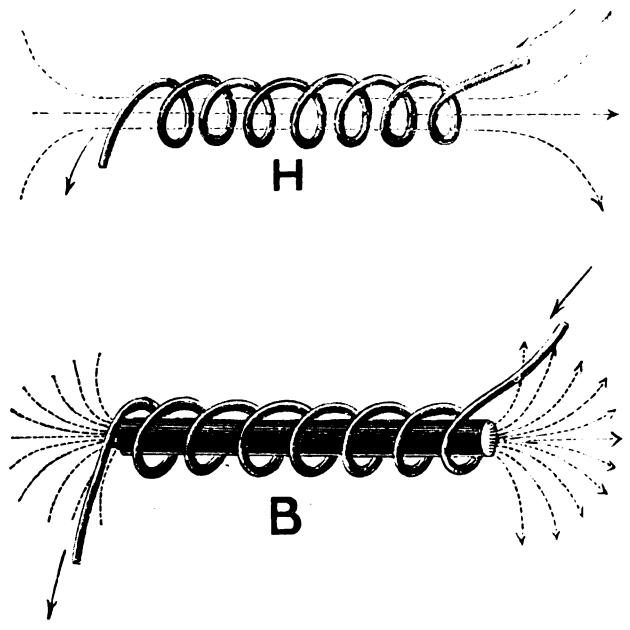

FIG. 121.

the intensity of magnetisation. Similarly, we have seen that the strength of a *permanent* magnet may be expressed in units of intensity of magnetisation, since the term only involves the lines of force due to its own magnetism, or the strength of pole of the magnet *itself;* but the same cannot be expressed in units of magnetic induction, since this term implies the presence of a magnetising force, and must include the value of the same.

Now, to understand what is the precise meaning of magnetic induction, let us take a simple cylindrical coil of wire as at H (Fig. 121). On passing a known current through it, a magnetic field of a definite intensity is set up in its interior. We have then a magnetising coil—that is, one capable of magnetising any magnetic metal placed within it. We have shown that the field intensity in the coil, or, what is the same thing, the lines per square centimetre, can be easily calculated. Suppose there are H lines per square centimetre through the ocil. Now, on putting an iron core inside, as at B, we find that the intensity of field becomes very much stronger than before; in fact, the presence of iron in the coil has enormously increased the number of lines. Now, what is termed "magnetic induction," or sometimes simply "induction," and denoted by the letter B, is the strength of field which exists when the iron is put in—that is, the number of lines per square centimetre. It must be remembered, however, that the part of this field B which we called H existed *before* the iron was put in, and therefore B – H lines have been *created* by adding the iron. We say created because they did not exist in the iron before it was put in the coil, neither did they exist in the coil space before. The lines B – H are therefore those due *alone* to the magnetism acquired by the iron, and these we have found above to be equal to $4\pi I$. We therefore arrive at an equation expressing the fundamental relation between "magnetisation" and "induction," viz.,

$$B - H = 4\pi I,$$

from which, if we know the magnetising force H and the magnetisation I, we can find the induction by

$$B = 4\pi I + H.$$

For example, by inspection of the upper curve in Fig. 119 we find that the magnetisation was 1,280 units for a magnetising force of 54 units. Hence the magnetic induction for this force was

$$4\pi\ 1{,}280 + 54 = 16{,}144 \text{ lines per square centimetre,}$$

of which 54 are due to the magnetising coil and 16,090 to the magnetism acquired by the iron. Working out a few values in the above manner we obtain data to plot a fresh curve (Fig. 122) for the same core, the vertical ordinates being now in C.-C.-S. units of magnetic induction or lines of force per square centimetre through the iron. This shows the connection between induction and magnetisation, and how one may be deduced from the other. It is possible, however, that the student may find some difficulty in conceiving the physical meaning of the

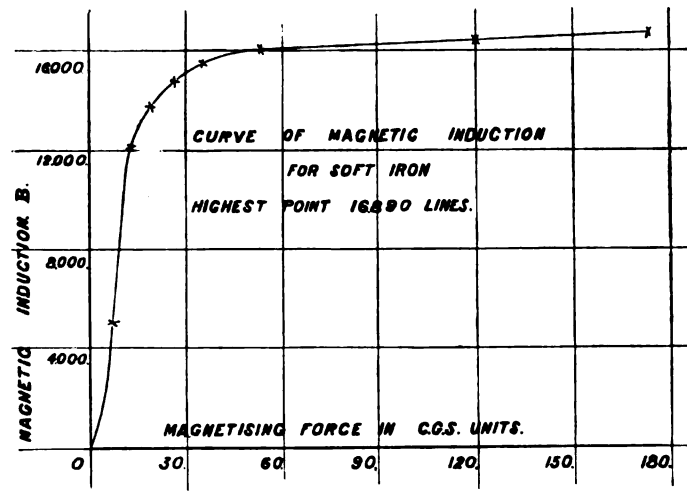

FIG. 122.

formula as applied to the reverse operation, viz., that of deducing the magnetisation from the magnetic induction. From what we have shown above, the formula is evidently :—

$$I = \frac{B - H}{4\pi}.$$

Now, suppose the value of B in a certain *ring* of iron under a given magnetising force H has been ascertained. It is simple enough to put these values into the above formula and so calculate I; but the physical meaning is not so simple to follow, for by I is meant the pole strength per unit area of metal, or moment per unit volume, while the piece of iron under test is ring-shaped, and, therefore, has no poles and no magnetic moment. The explanation is that for a given pole strength per unit area, the mass of the iron is in a certain definite condition magnetically, which can be represented as equivalent to a definite field or number of lines per square centimetre, running through its substance. Now, it is clear that this identical magnetic condition of the iron, as regards the number of lines through it, can exist equally well when the iron forms a closed circuit, and exhibits no polarity at all; indeed, we have already shown that the internal field equivalent to a magnetisation I is represented by $4\pi I$ lines, and therefore the formula is quite intelligible. With a ring-shaped iron core the magnetisation cannot be determined by a magnetometer, as there are no poles

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to act on the needle, but it can be calculated in the above way from a direct experimental determination of the magnetic induction.

140. *Practical and Asbolute Magnetic Saturation.*—It will be noticed in the above curve that magnetic induction in the iron, up to 12,000 lines, takes place very rapidly under the action of 10 or 12 C.-G.-S. units of magnetising force, and that as the force is increased beyond this point induction occurs more slowly. For instance, double the force (24 units) only produces 14,700 lines, or an increase of a little over one-fifth the field. Again, three times the force (36 units) only produces 15,700 lines, or an increase of about one-third the field. And it will be seen by the curve that any further increase in the force produces but slight increase in the induction; in fact, for practical purposes, it would be very uneconomical to expend 180 units of magnetising force to produce 16,900 lines, when 16,000 could be produced with less than one-quarter the force. It is for this reason that the top bend of the curve just before it becomes almost horizontal is taken as the practical limit of saturation, and in soft iron may be taken as about 16,000 lines.

In the best quality of iron now obtainable, such as Swedish charcoal iron or well-annealed wrought iron, the induction curve rises quicker, and reaches considerably higher values. For dynamo armatures built with iron of this quality a fair average saturation met with in good machines ranges from about 18,000 to 20,000 C.-G.-S. lines, or sometimes higher. The point of "absolute saturation" is of purely theoretical value, and, of course, means the point at which the curve ceases altogether to rise. It would appear that there could be no absolute saturation point for magnetic induction, because the magnetising force is one of its constituents, and it would, therefore, seem probable that induction would always increase with

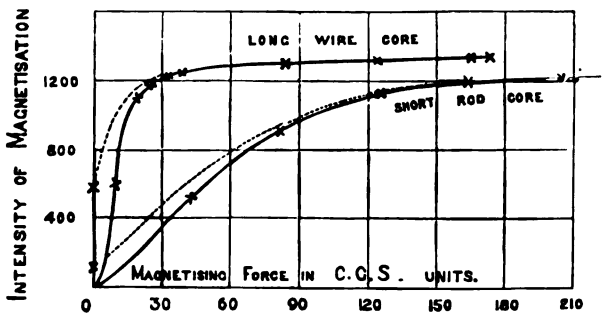

FIG. 119.

an increase in magnetising force. To determine this question evidently requires the employment of exceedingly high magnetising forces, to obtain which the magnetising coil, as applied directly to the specimen of iron under test, is out of the question. The researches of Prof. J. A. Ewing and Mr. William Low in this direction furnish by far the most advanced experimental data on the subject, inasmuch as these able observers have for some time brought to bear upon the specimens of iron under test far higher magnetising forces than have been hitherto employed. Their method consists in placing the piece of iron under test between the poles of a powerful electro-magnet, so as to form a complete magnetic circuit, and thus force a large number of lines through it. To increase the density of lines through the test piece it is thinned at the centre by turning down to a very small diameter, while its two sides extend outwards, cone-like, to fit the pole-pieces. This gives the test piece the shape of a reel or bobbin, of which the thin central portion is called the neck. By this means, as communicated to the Royal Society in their recent Paper (November 22, 1888), the authors have forced the magnetic induction in wrought iron to the enormous value of 45,350 C.-G.-S. units, and in cast iron to 31,760, and find that there is no appearance of a limit to the extent to which magnetic induction may be raised. To show what an advance this is, a remark of Drs. J. and E. Hopkinson in their able Paper on Dynamo-Electric Machines in 1886 *(Phil Trans.)*, may be quoted, "No published experiments exist giving the magnetising force required to produce the induction here observed in the armature core amounting to a maximum of 20,000 per square centimetre."

The direct measurement of the induction was made in the usual way; the central neck, where the induction is greatest, was wound with a coil of wire connected to a ballistic galvanometer, and the "swing" on the latter observed when the iron bobbin was turned round through half a revolution, so as to face the opposite poles of the electro-magnet. As this completely reverses the direction of magnetisation, the deflection is proportional to twice the induction in the bobbin. We shall refer again to the ballistic galvanometer and the method of calibrating it in absolute units by the use of earth-coils. The measurement of the exact value of the magnetising force (necessary in order to calculate the intensity of magnetisation) was attended with great difficulty, and it was not until the Paper referred to above that the authors were able to speak with confidence of its determination. The method was to wind a second coil at a certain measured distance concentrically round the first, and to subtract the deflection obtained with the first coil from that obtained with the second, the difference being proportional to the field within the air space between the two coils. To investigate how nearly this field approximated to the magnetising force acting on the metal, was a determination of great difficulty, but the authors say in the above Paper that by modifying the form of the cone-shaped sides of the iron bobbin a uniform field was obtained in the central neck, and the magnetising force within the neck was sensibly the same as that in the air immediately around it.

Having established the correctness of the determinations of the magnetising forces employed it was found that for wrought iron the intensity of magnetisation remained stationary at 1,700 C.-G.-S. units, while the magnetising force was varied between the enormous values of 2,000 to 20,000 C.-G.-S. units, showing that apparently a point of "absolute" saturation as regards magnetisation may be reached. This saturation point for cast iron is found by the authors to be 1,240 units. The point of "practical" saturation for soft iron will be seen by the curve obtained above experimentally (Fig. 119) to be about 1,300 C.-G.-S. units.

(To be continued.)

NEW CATALOGUE OF THE GENERAL ELECTRIC COMPANY.

Messrs. Binswanger and Co., who trade under the above title, have just issued a catalogue of electric lighting plant and material which is probably the most complete and exhaustive list of electric lighting apparatus which has yet been issued; every possible requirement, from a one shilling cut-out to a 100 horse-power engine, is to be found within these pages. The book is of quarto size, and consists of 80 pages of closely printed matter, with nearly 300 woodcuts, most of which are new. It is evident that special regard has been had to the requirements of the trade which is now springing up in connection with central station lighting. An increasing number of non-electrical firms are now engaged in the wiring and fitting of houses, and for this class the information here contained will prove invaluable. Under general headings the following articles are catalogued:—Switches, cables, lamps and holders, cut-outs, electricity and potential meters, glassware, brass and other fittings, arc lamps and carbons, list of various dynamos and motors, accumulators, engines, insulators, and various sundries and estimates. The whole of the switches and cut-outs supplied by this company are mounted on porcelain bases, as recommended by the fire insurance offices, and the designs are of a safe and substantial description. Much attention has evidently been given to the design of electroliers and glass fittings, many of which are of very beautiful character. We are glad to observe that an effort has been made to reduce all screws and tubes to standard sizes. It is also satisfactory to note that there is a decided tendency to a reduction in price, especially of small fittings, compared with those which were ruling a year or two ago. We strongly recommend our readers who are interested to endeavour to secure a copy of this valuable work.

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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"The Electrician" is on sale at the railway bookstalls throughout the United Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.

SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
	s. d.	s. d.	s. d.
For Foreign Parts and Colonies:— Within Postal Union	6 6	12 6	24 0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

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Particulars relating to Advertisements will be promptly forwarded on application to this office.

Trade Advertisements *intended for the current issue must be handed in not later than First Post on Thursday morning.*

Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

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"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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At the commencement of each year is issued The Electricians' Directory and Handbook. *The Directory was established in 1883, and has now attained considerable proportions. Every care is taken to make the names and addresses of all persons engaged in the Electrical Industries absolutely accurate. Useful Tables and Electrical Formulæ are given, together with popularly-written Biographical Notices of the leading Electricians, accompanied in many cases by Portraits.*

THE DIRECTORY FOR 1889 IS IN PREPARATION.

CONTENTS OF THE CURRENT NUMBER.

Notes 183
Lightning Conductors.—VI. By Dr. Oliver Lodge. Continued 188
Mr. Mackie's Report on the Paddington Electric Lighting Scheme 189
Letters for Learners and Unprofessional Readers. By H. D. Wilkinson. Illustrated. Continued 191
New Catalogue of the General Electric Company 193
Election or Nomination? 194
The Society of Telegraph Engineers and Electricians— Report of the Council, &c. 195
"A System of Electrical Distribution." *Discussion.* Ill. 196
The Transition from Metallic to Electrolytic Conduction... 199
Snelgrove's Electric Bell. Illus. 200
Barcelona International Exhibition. Awards 200
Legal Intelligence— Edison and Swan Electric Light Company *v.* Holland and Others 200
American Notes 202
Correspondence 204
Companies' Meetings, &c.— Swan United Electric Light Company 205
Pilsen-Joel and General Electric Light Co. (Limited)... 207
Woodhouse and Rawson (Limited) 207
Maxim-Weston Electric Co. . 209
New Companies Registered ... 209
City Notes, &c. 209
Companies' Share List 210

VOLUME XXI. OF "THE ELECTRICIAN."

Volume XXI. of "The Electrician" is NOW READY,

Price 12/6, post free 13/6.

NOTICE.

It has been found necessary to defer the publication of the Portrait of SIR WILLIAM THOMSON, announced in our last issue, until next month.

ELECTION OR NOMINATION?

It will be seen from our report of its last week's proceedings that the Society of Telegraph-Engineers and Electricians enlivened the period of suspense while the votes were being counted by debating whether in future the annual vacancies on the Council shall be filled by nominees of the Council who are in office, or be elected by the members of the Society at large. This, at all events, is the issue that was raised, although in springing the motion upon the meeting unexpectedly the mover did not state it in those blunt terms. Fortunately a decisive vote was not taken upon the subject, but was postponed to give time for further consideration. The act of submitting the question to the members present was a virtual confession that they had a right to be consulted, and to have taken their vote upon it without notice would have been in the highest degree impolitic. Had the Council simply reverted to their former practice of naming only a sufficient number to fill the current vacancies, and if called to account professed their inability to name more than that number, or their deliberate conviction that to have done so would have been injurious to the welfare of the Society, something might have been said for such a course. But for the course actually pursued hardly anything can be said, unless, perhaps, it may be taken as an indication that the Council itself is not unanimous on the subject, and by way of compromise has allowed it to be brought before the members as an open question.

Taking this view of the situation, it will be only fair to allow those who are most intimately asssociated with the management, and responsible for its efficiency, to have their say, and to do their utmost to persuade the members to forego the privilege which they have exercised at the last three or four annual elections. Mr. Preece said a good deal that was cogent for his view of the case, but spoiled it somewhat by saying too much. It is idle to tell the members that they can dismiss the Council if it does not discharge its functions properly. For some

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flagrant misconduct, which it will never be guilty of, possibly the Council might be got rid of; but in the matter under discussion that body is already unassailable, and the proposition now put forward would tend to make it still more so. Of course members of the Society—that is to say, the present electorate—will take this fact into account in forming their final judgment, as well as the *pros* and *cons* of the case as submitted to them by the Society's executive. But this is not all; they will have to seriously consider whether the members themselves have shown, or are ever likely to show, such warm interest in the election of the Council as to combine or agree upon a "ticket," as the Americans say, or list of names from which a choice is to be made. If the members will not do this, the Council must; and our own belief is that what the former desire is not so much to take away the nominations from the Council as to retain the right to vote upon them.

From what has been said above it will be seen that the actual privilege exercised by members is neither very considerable nor very valuable, and that, consequently, the loss of it would not be a very grievous hardship. But there is one hardship which no man of sense cares to submit to, namely, that of having to go through an empty and meaningless formality. It was this that led to the so-called "agitation" resulting in the present mode of election, which it is now proposed to abandon. If we are not mistaken the original method was the same as it is now, but it drifted into the one which Mr. PREECE wishes again to fall back upon. For some years previous to the "house list" being extended the election was a spectacle only fit to provoke laughter. A few unsophisticated members in the country sent up their papers by post; a few others, chiefly new intrants, crept sheepishly down the gangway and discharged their solemn functions in the well of the theatre. When the neighbouring clock-tower chimed the fatal half-hour, the sacred urns were carried away by the scrutineers, while the audience tried to screw their countenances into an appropriate semblance of anxiety. Presently, and before Big Ben can strike the full hour of nine, the result is silently conveyed to the Secretary, who, with a gravity for which we hope he will one day be rewarded, announces that Professor This and Doctor That are the gentlemen who have been duly elected. He might have said unduly with greater truth; for a more unnecessary and undue ceremony could hardly be conceived. If this is an election, then eggs may be said to elect their sitting hens, and Churchmen their Episcopal rulers.

The excuse put forward by the Council of the Society is that to nominate more candidates than are required leads to heart-burnings and needless humiliations. So far as it concerns the Council, the argument is good, but not as concerns the members. To be officially invited by the governing body of the Society to stand for election is indeed vexatious if it ends in being rejected by the members. Nobody cares to be set up as a nine-pin for people to shy at, especially when five out of nine are bound to be knocked over. It would be different, however, if the nominations were the members' own; and whether by circular letter inviting their recommendations, or by general meeting to receive them verbally, such a method of ascertaining the preference of the electorate has much to recommend it. It would have the merit at once of leaving the members no room for complaint, and the Council still plenty of room for nominating their own men with a tolerable certainty of their being elected—freely as well as duly.

Of course we are offering these suggestions only on the assumption that the question, having been raised, will have to be adjusted between the Council on the one hand and the Members on the other. We fancy it would have been wiser not to have raised it at all. But as matters have taken this turn, they will be settled probably by some sort of compromise more or less resembling those we have hinted at. One other may be mentioned here in conclusion. The election of Associate Members is not precisely on the same footing as that of Ordinary Members, and it might be possible for the Council to name more than the requisite complement of Associates, while refraining from naming more than the complement of Members, without giving occasion for personal offence which the Council is so anxious to avoid. There is plenty of time, however, to think these details carefully over. What the Council have to bear in mind is that the members do strongly object to play at make-believe in registering a foregone conclusion which goes by the name of an Election. On the other hand, what the electors have to remember is that a delicate and onerous task, if it devolves upon them, is still more delicate and onerous when it falls upon the Council; and, further, that in the present mode of election, with which they are satisfied, the electors do nothing but reject or accept the Council's nominations, initiating none among themselves. They certainly ought to be allowed sufficient time to try; and the Council could not do better than to give them the opportunity and see what would come of it.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

ANNUAL GENERAL MEETING.

The annual meeting of this Society was held at the Institution of Civil Engineers, on Thursday, 13th inst., Mr. Edward Graves in the chair.

The SECRETARY (Mr. Webb) reported the death of M. Gaulard, who died on the 22nd of last month.

The CHAIRMAN said he was sure that he was expressing the feelings of all the members present when he gave expression to their most sincere regret at the death of M. Gaulard, who for many years was the special apostle of the new system of electric lighting. He lived to see many people adhere to his views, but he unfortunately died before reaping the practical advantages accruing from his inventions.

The SECRETARY (Mr. Webb) read the

REPORT OF THE COUNCIL,

as follows:—

"The Council have satisfaction in reporting that the number of new members elected into the Society during the present year considerably exceeds the average, including 19 foreign members, 9 members, 104 associates, and 36 students, or a total of 168; and 35 candidates have been approved for ballot at the first meeting next month. Sixteen associates have been transferred to the class of members, and 16 students to the class of associates. The number of deaths, although not quite so great as last year, has been considerable. We have been thus deprived of five foreign members, Senor Ugarte, Inspector-General of Telegraphs at Buenos Ayres; M. Jules Raynaud, of the French Telegraph Administration, whose death took place under lamentable circumstances; Mr. L. Bigelow Jones, of Cordareille, Mass., U.S.A.; M. Gustave Cabanellas, the well-known French writer on electrical subjects; and Don José Rodriquez Vera, of the Spanish Government Telegraphs. Seven members, including our late president, Sir Charles Bright, whose services in nearly every branch of electrical engineering, but more especially in connection with land and submarine telegraphs, are well known; Mr. Thomas Russell Crampton, who was intimately connected with the first successful submarine line, and was eminent also as a civil and mechanical engineer; and M. Gaulard, whose name must always remain identified with the transformer system of electrical distribution. Eight associates—amongst whom are Mr. George Mason, manager of the Telephone Construction and Maintenance Company; and Mr. George Henley, of the Henley Telegraph Works Company—four foreign members, nine members and 14 associates have retired from the Society during the year.

"The general meetings of the Society, which by the liberality of the Institution of Civil Engineers continues to be held in the lecture hall of the Institution, have been seventeen in number, inclusive of four extra meetings; and the Council have arranged, by the kind permission of the Institution, to hold next year sixteen meetings on fixed dates, and, should occasion arise, one extra meeting.

"The average attendance is increasing considerably, and the Papers read during the season have, as usual, ranged over a variety of subjects, as will be seen by the subjoined list, and have in most cases given rise to important discussions.

[The Papers and discussions have appeared in *The Electrician*.]

"The Council have awarded the Society's annual premiums in respect of Papers read during the twelve months ending the 31st May last, as follows:—The Society premium, value £10, to Prof. Silvanus P. Thompson, member, for his Paper entitled 'The Influence Machine from 1788 to 1888;' the Paris Electrical Exhibition premium, value £5, to Mr. A. C.

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Cockburn, member, for his Paper on 'Safety Fuses for Electric Light Circuits, and on the Behaviour of Various Metals usually Employed for their Construction;' the Fahie premium, value £5, to Mr. Edward Stallibrass, member, for his Paper on 'Deep-Sea Sounding in connection with Deep-Sea Telegraphy.'

The Council desire further to highly commend the original communication by Mr. E. O. Walker on 'Earth Currents in India,' published in Part 71 of the *Journal*, and which is practically a continuation of previous valuable communications on the same subject contributed by that gentleman.

"With the view of inducing those who take part in discussions at the Society's meetings to condense their remarks as far as practicable, and with the further object of affording more opportunities to the younger members of joining in the discussions, the Council have introduced the following rule, which, so far, appears to have met with the approval of the members generally, viz., 'That when a speaker shall have occupied ten minutes the chairman shall sound a bell, and if the speaker do not close his remarks within the next two minutes the question shall be put to the meeting whether or not he shall be permitted to continue them; but the chairman shall have authority to suspend the rule on exceptional occasions.'

"The Committee on Electrical Nomenclature and Notation have prepared a draft report, which has been carefully considered, but it is not yet sufficiently advanced to be submitted to the full committee for final approval.

"The committee appointed to revise the rules and regulations issued by the Society in 1883 for the prevention of risks of fire arising from electric lighting, hoped to have been instrumental in bringing about the general adoption and recognition by all the fire insurance offices of one set of rules, to be modified from time to time as occasion required, by which much inconvenience, both to the offices and to electrical engineers and contractors would, in the opinion of your Council, be avoided. In the endeavour to effect that desirable object they were warmly seconded by the Fire Offices' Committee; but owing to the attitude taken up by at least one of the leading offices, the Committee of the Society found themselves compelled to limit their recommendation to a revision and amplification of the general rules of 1883, leaving the insurance offices to issue such other rules of a more detailed nature as they might think fit.

"Her Majesty's Government having decided to take no official part in the forthcoming Universal Exhibition at Paris, the Society was requested by M. Berger, the Director-General, to place itself at the head of the movement being made to induce the representatives of electrical science and industry in this country to take part in the Exhibition, and practically to take charge of that section.

"Your Council consented, as a preliminary step, to ascertain how far British electric manufacturers were likely to become exhibitors, and accordingly appointed a committee for that purpose, it being understood that upon the result of their inquiries must depend whether the Society would be justified in undertaking the functions which the Director-General desired them to fulfil.

"The response to the Committee's circular, which was widely distributed, was so unsatisfactory that the Council were compelled to decline M. Berger's request.

"The President of the Society and several members of your Council have been nominated on a committee called the Mansion House Committee of the 1889 Paris Exhibition, of which the Lord Mayor is the president, and formed to watch the interests of British exhibitors generally, and such of those who purpose to exhibit in the electrical section are sure to be cared for.

"The Council are glad to report that the class of students continues to increase in numbers, and that all the students' meetings have not this year been so largely confined as last year to the discussion of Papers read and already discussed at the general meetings, but have included the reading of several original Papers of considerable merit. The necessity for further library accommodation has been felt for some years, and has at length compelled the Council to rent an additional room on the same floor as those already occupied by the Society. Two new book-cases have been purchased, and two others have been most kindly presented by our member, Sir David Salomons. The shelf space thus provided will, it is hoped, meet the increasing requirements for some years to come.

"The financial position of the Society continues sound; but the additional expenditure involved by the increased number of meetings, the corresponding increase in the amount of printed matter in the *Journal*, and by its publication and issue at more frequent intervals, together with the rent of the new room, and purchase of bookcases and furniture, will, it is expected, be found to have absorbed the increase of revenue arising from the large number of new members elected during the year.

"Since the last annual general meeting two *conversaziones* have taken place; one given by our lamented late President, Sir Charles Bright, on the 18th of December last, and one by our present President, Mr. Edward Graves, on the 15th of July last. Both of these *réunions* were held in the galleries of the Royal Institute of Painters in Piccadilly, and were largely attended.

"The replies received to the circular issued by the Council in February last, for the purpose of gauging the opinions of members of all classes as to the proposal to change the name of the Society fully bore out the expectations of the Council, having practically amounted to a unanimous approval. The necessary legal steps have therefore been taken to enable the Society to assume, on the first of next month, its new title of 'The Institution of Electrical Engineers.'"

The adoption of the report was moved by Sir DAVID SALOMONS, and seconded by Mr. CROOKES.

The usual votes of thanks were then moved and seconded to the Institution of Civil Engineers for their hospitality; to the local Hon. Secretaries and Treasurers abroad; to Mr. Graves, as Treasurer; to Messrs. J. Wagstaff Blundell and F. C. Danvers as Hon. Auditors, and to Messrs. Wilson, Bristows and Carpmael as Hon. Solicitors.

The PRESIDENT then announced that they would resume the adjourned discussion of Mr. Edmunds' Paper on

"A System of Electrical Distribution."

Mr. MORDEY: The meter which Mr. Edmunds proposes to use appears from the description simply to add up the number of charges received by the cells in a given time. This writer did not, so far as he understood the author, take any note of any loss that might occur on the line or in the cells, and in the event of the people at the station supplying, say, 50 or 60 amperes instead of 70, it appeared that the meter still charged the customer for 70 amperes. What safeguard had the consumer that the meter really measured anything? No doubt some check was provided.

Mr. EDMUNDS, in reply, said: Since reading my Paper on Electrical Distribution I have carefully considered the discussion thereon, and also noted the various comments of the technical journals. It has occurred to me that I did not give sufficient data in order to make the system fully understood. Mr. Mordey's question is one that shows that, and I will answer that question first. The arrangement that we use for metering is a solenoid, through which the current passes when it comes from the charging main into the batteries. But this solenoid is so weighted that if anything but a 70-ampere current goes in it does not respond. The consequence is that if the station sends out 60 amperes they do not have any record, whilst if they send out more it is at their own loss. Mr. Mordey says that it is hardly fair to charge for what goes out; but that can be got over by charging a fairly low rate per unit, say 6d. per unit. I claim for the system something more than a set of complicated mechanical devices for attaining certain ends which might be attained by much simpler means, or might be shown to be unnecessary. Therefore, if you will allow me, I will not merely reply to the several questions raised, but will add something to my previous remarks, in order to make you more intimately acquainted with the subject. If, therefore, in this reply I should either repeat myself, or give you obvious or well-known information, I must beg you to excuse this on the grounds that I wish to be fully understood. I have decided to reply to the several speakers as a whole rather than in detail. First, let me express my thanks for the recognition accorded by the members to the ingenuity of the scheme, for such recognition is most encouraging, and is one of the most valuable recompenses one can obtain. I also appreciate the various suggestions made as to the desirability of simplifying the details, and removing unnecessary parts. I think that there was a feeling at the last meeting that the machine was fearfully and wonderfully made. I am glad to say that since I was here I have entirely remodelled the apparatus, and instead of the 32 contacts we have now only eight, and it now occupies a space of less than 18 by 12 by 7½, and instead of costing about £25 to make, they ought to be produced at less than half that sum (applause); in fact, instead of being an experimental model it is a practical working instrument. What is still more important, the new instrument, being free from all springs and cams, it can never, under any circumstances, open the circuit and cause the light to go out. All the changes are made by giving an alternative path to the current through the cells or through a suitable resistance. I think that Mr. Reckenzaun considered that the fumes of gases evolved from the cells were rather harmful to an arrangement of that kind, but by placing over the cells a solid paraffin cover, I find that we do not evolve gases. The hydrogen gas comes off very slightly, and is discharged as a bubble; and although charging with a current of 70 amperes, and carrying on a charge for 24 hours, and bringing up the batteries to a high point of charge, we have not any great amount of gas liberated. Now comes the question as to the necessary charging potential. I said in my Paper that we could charge cells intermittently to their full charge with a mean voltage per cell of 2·25, instead of a constant 2·5 volts per cell as is required where cells are charged continuously, and I wish to explain this, and to show why this differs from ordinary practice alluded to by Mr. Reckenzaun. In the first place, I said a mean or average voltage, and not a constant potential. We have a constant current of 70 amperes, and that is our only constant. The charging potential varies with the change in counter E.M.F. in the cells, due, as Mr. Reckenzaun points out, to the hydrogen gas in a nearly fully-charged cell on the negative plate giving a fictitious electromotive force. But these are the very points of difference between ordinary practice, such as Mr. Reckenzaun refers to, and the system employed here. Let us try and disabuse our minds about a fully-charged cell as ordinarily understood, which would mean a condition where, after many hours' *continuous* (not intermittent) charging, we get in a set of cells a counter E.M.F. while being charged of, say, 2·5 volts or more, this being the point when it is usual to consider a cell as fully charged, and then we cease charging. If we take this diagram here [hanging on the wall] I will explain what I mean. I believe the practice is to charge the cell for a given number of hours, as is shown, with a 60-ampere current. After charging for one hour you find a rise of the potential at the terminals of the cell from about 2 volts to about 2·15; then as you go on charging it continues practically constant until you come up to 2·2 volts, but that is when you have got five hours into the battery, or 300 amperes. Since I was here I have tried an experiment. I took cells and charged them intermittently. I found that by giving a cell a two minutes' charge—I took the potential of the cell previous to conveying it to the charging circuit—and found 2 volts. When I put them into the charging circuit with 70-ampere current, I found a rise from 2 volts to 2·1, but in two minutes I had only got from 2·1 to 2·2. Now, if I continue the charging—I am speaking of the cell with 300 amperes in it—beyond two minutes I find the cells have a tendency to gas, and then we get a fictitious E.M.F., but if we discontinue the charge at the end of two minutes we have been enabled to pass that in at a charging potential of 2·2. I can add these increments of charge, and I can bring the total ampere-hours into my cells as a whole in 24 hours in the way in which we desire, and yet never have a charging potential of more than 2·25 volts.

But now comes the question. To what point do we charge them? How much energy can we get into them, and how much can we get back again?

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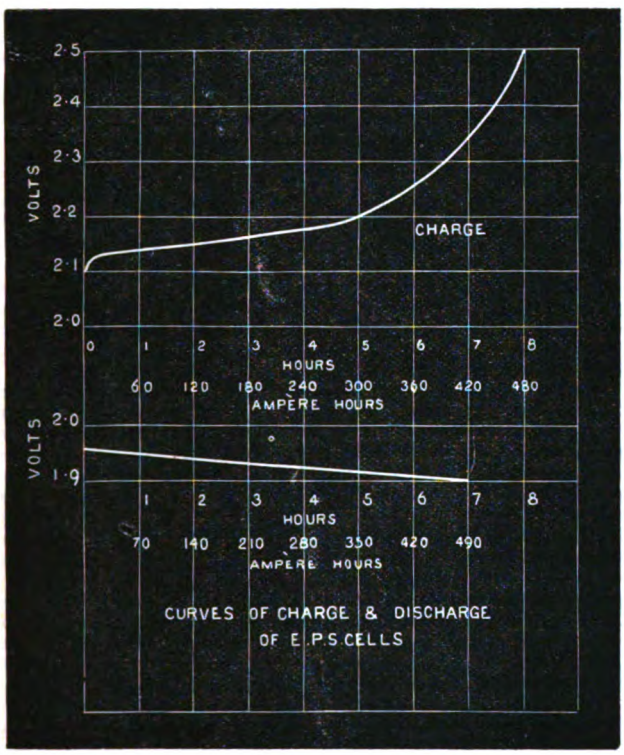
What are the dimensions of the charging station plant, and what does it cost to operate this system? With regard to the charge in the cells, Mr. Bate remarked that the cells would have to be very much larger than would be necessary if the batteries were allowed to discharge at their full rate, and then replaced by others of equal capacity, by which means we could get twelve hours' charge and discharge, whereas here we could get only six hours' charge out of twenty-four. If Mr. Bate's conclusions were correct, I certainly should not feel justified in taking up your time in bringing such a system to your notice; and here again I feel that fuller explanation is necessary, and I will, therefore, take an example of what we would do in actual practice. Suppose we determined on only having 2,000 volts potential at our station and a 70-ampere current. This would represent 140,000 watts. We can use in our station six dynamos, each giving 400 volts by 70 amperes, and each driven by a separate engine. This would provide an ample margin of power, allowing us to use a ten-mile circuit, which would demand an additional 300 volts, bringing up a total voltage of 2,300 volts. In addition to this plant we should have two spare engines and two spare dynamos, making, in all, eight dynamos and eight engines. We should also provide four boilers, leaving one over as a reserve. Now, let us consider what we can do with such an amount of plant in the central station, and see how many batteries we can charge on circuit. This will give us some indications of the value of the system on a large scale. We can divide our 3,600 cells, so that they can supply 112 centres. Each centre would be capable of supplying current locally of 48 volts by 70 amperes for eight hours, provided the station were run for 24 hours. This would practically enable us to maintain at each of these centres seventy 16 candle-power lamps, or a total of 7,840 16 candle-power lamps on an extended circuit of 10 miles, divided over 112 places.



Now, what would such a plant cost, and what would the running expenses be? Also, what would be the scale of profit? This, I think, is a most important feature for consideration in such a Paper as this, and I am glad to say that I am prepared with figures from actual experience on this point. From first-class contractors I learn that we can have our eight dynamos, eight 50 horse-power engines, four 100 horse-power boilers, and the preparation of the building, the instruments, and ten miles of circuit with the wiring necessary for the fitting in the houses, and the sundries included in the station and on the circuit, for £12,000. In addition to this our 3,600 batteries, taken at the list price of £6 each, would come to the large item in batteries of £21,600. Our 112 distributors, one at each centre, say at £10 each, would come to £1,120. The erection of batteries would cost the company, say, another £1,000; but the consumer would in most cases be asked to supply a room, and, at any rate, pay for the fitting up of the batteries, so that these need not be charged wholly to the supply company. This would give us a grand total of £35,720. Now, let us see what it would cost to run this station at 24 hours a day for 365 days in the year with these engines and these dynamos and the three boilers running continuously day and night, so that practically we should be taking the outside and maximum cost that this plant could represent. We will allow per horse-power 4lb. of coal, which at 240 horse-power for 24 hours a day and 20s. a ton, gives us a total of £3,756 for fuel. We will then take oil and waste at 6s. 6d. per night, which would give us £119. Take the water at 1s. per 1,000 gallons, that would give a total of £300. We will allow for wages £,1,565. We will take rent and taxes at, say, £500, and those items will give us an annual expenditure of £6,240—that is to say, if we run this station without any regard to the demand for 24 hours in a day or the whole year. Now, we will say that we get a revenue of sixpence per unit of the current passing into the batteries, which by the system of metering proposed we could ask. This would give us on the output of such a station a gross revenue of £84 per day, or £30,660 per annum. But such a revenue would only be obtained if the total amount of energy in this station were consumed for eight hours per day throughout the year. I have therefore made a calculation as to the revenue accruing from a less consumption than this. We will take, for example, an average of only one hour per day in the year for the output of the station. That would give us a revenue of £3,832. 10s., and for four hours per day this figure would be £15,330; and this latter is probably about the average throughout the year that we could depend upon. This would only necessitate the station working for an average of 12 hours per day instead of 24, in which case we should cut down the fuel charge one-half, reducing that to £2,000, and our wages might be reduced by one-third, leaving that item at £1,000, and the rent remaining the same would give us a gross cost for running of £3,500 per annum on a gross revenue of £15,330, leaving us £12,000 to the good. This, however, would be by no means all profit, as we must now allow for the depreciation of the machinery and batteries. It is usual to write off 10 per cent for machinery, which for our engines, dynamos, and boilers would be £600. The depreciation of the batteries is more of an unknown quantity. My own idea is that 10 per cent. per annum ought to cover these, but we will put it at 15 per cent.—£3,240, which is a liberal depreciation. This would leave us a gross profit of £7,990 on the supply of current for an average of four hours per day. Placing the capital at £40,000 this would give us a profit of 20 per cent., and this, I think, is a most attractive feature in the system (laughter). Of course, it is often said that figures could be made to prove anything, but I think I have dealt very liberally with all the cost of the plant and the depreciation, and should we increase the demand from an average of four hour hours per day you will understand that the profits mount up very rapidly. This is the best reply that I could make to Mr. Bate and to other gentlemen who made similar remarks.

Mr. Preece and Mr. Bate thought that the proposition to run an engine without a governor was a novel one, but I can assure them that there is no difficulty in achieving this in practice. Nor do we pay too heavily in our coal bill, as Mr. Kapp feared we might, for I find that in our high-speed engines actually in use, instead of the coal being 4lbs. per horse-power we use in practice about 3lbs. to evaporate about 30lbs. of water. We get over the difficulty of slow speed by having a suitable number of small engines, and the E.M.F. required to charge the ten-mile line being about 300 volts, we can always ensure our engines, as we arrange them, running at least at 150 revolutions per minute. We have not found in practice that any difficulties have occurred in this direction.

Prof. Forbes raised a question about lamps having 2½ watts efficiency. I remarked *about* 2½ watts. I did not say that it was actually 2½ watts. I find on investigation that with an actual 2½ watts they blacken too soon, and though the filaments last 1,000 hours, the lamps are not so useful, owing to the blackening and higher resistance, for more than 400 or 500 hours. But if we can take them at 2·7 or 2·75, with a perfectly constant potential, so that we do not overstep the mark even for a short time, we can safely rely upon the lamps coming up to their 1,000 hours. I find that a very slight difference in temperature when working at this high potential is enough to cause all the difference between length or shortness of life in the lamp, and therefore, with such a system as the one contemplated, it is important to know that we can depend upon a certain potential which is practically constant at all times.

Several allusions were made to the undesirability of introducing motor generators into this system. I do not think that they are essential, but I think that they form valuable auxiliaries, and I think it is well to look to the absorption of more current from the charging station by means of motor generators and electro-motors, than would be taken by the demand on the batteries in order to increase our revenues. Further, the cost of batteries is the most heavy one in this system, and although we have enormous advantages when they are going to be used to their full capacity, yet, should we have to meet a large demand for a very short time, it would probably be better to have a small number of batteries, with the auxiliary of a motor generator, than to have the larger number, with their interest and depreciation going on, and which interest and depreciation could not be equal to the revenue accruing from them. That is why I deemed it desirable to have an auxiliary of this kind, but it is only an auxiliary, and not a necessary part of the system.

The important features of my system are the reduction and simplification of the plant in the charging station, not necessitating that the engines should be running all the time at an absolutely constant speed, and requiring the particular attention such conditions demand. The reduction of the potential at the charging station to a point not exceeding 2,000 volts, which, as we have seen, is sufficient with a 70-ampere current to supply an eight hours' demand of 8,000 sixteen-candle-power lamps on a 10-mile circuit. Or, by increasing the batteries and running on a double line (or, as I suggested last time, in the alternative method, where the charging station is to supply four hours' discharge, which is the amount we have based our revenue upon) would allow double the amount of work in a 24 hours' run at the station, thus giving us 16,000 lamps. All those points are very desirable in the interests of economy and safety. The absence also of any high potential on the local lines of the system is a feature of great importance, getting over the vexed question of highly insulated wire. The assurance that, even should there be an accident at the station, or an interruption of the line, there is always a reserve throughout the entire system, and the bringing of the local batteries near to their work, thus considerably reducing the cost of mains, all point to the commercial as well as to the electrical and mechanical advantages of this system. I think that I have now probably answered all the questions that I was asked, but I shall be glad to reply to any further ones (applause).

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The PRESIDENT, in moving a vote of thanks, said that the Paper was more especially notable for this, that Mr. Edmunds, in the interval that had elapsed since his Paper was read, had shown that he appreciated the value of the criticisms passed upon it, and he had accepted them to such an extent that he had actually reduced the cost of his apparatus by one-half. That showed the practical advantage of adjourning the reply, and perhaps in future they might follow this precedent to a large extent (laughter).

PROPOSED ALTERATION IN THE METHOD OF ELECTING THE COUNCIL.

The PRESIDENT said that Mr. Preece was burning with a desire to express his views on a matter that was of great interest to the members of the Society.

Mr. PREECE said he wished to call attention to the present method of electing the Council of the Society. It was the custom at one time for the Council to submit a list of those whom they recommended for election, and this was a practice followed by nearly every learned society, including the Royal Society, the Society of Arts, and the Physical Society. There was an exception, however, in the case of their own parent society, namely, the Institution of Civil Engineers, whose practice it was to submit a long house list, which comprised not only the names of the existing Council who were eligible for re-election, but also the names of many others whom the Council held to be sufficiently eminent to be elevated to the executive, and whom they left to the members to elect. In their own Society, owing to a little agitation that had originated in that room at the annual meeting, it was suggested that the members had not sufficient choice or sufficient voice in the selection of those who were to represent them on the Council; but speaking as a member of the past Council he could say that nothing afforded them more gratification than to have their proceedings criticised or to have suggestions made for their consideration, and if those considerations were of weight they had always been accepted and thoroughly carried out. However, they had submitted to the members for two or three years, as they had that night, a list containing many more names than the number that constituted the Council itself, but he was sorry to say that that course had succeeded very badly indeed. In the first place, men of eminence and of position would not submit to a process of competition. When they were asked to allow their names to appear on the list to be submitted to the members for election they declined to be put into competition with brothers in their own profession. The result was that the best men would not consent to their names appearing among those of the candidates for selection. Again, there were many who had agreed to allow their names to appear on the house list, and who had been rejected in the process of competition; and he was sorry to say that there were two or three men whom he could name, but he thought it would be invidious to mention them, who had been very constant in their attendance at the Society's meetings, had evinced an absorbing interest in the Society's welfare, and who had taken an active part in the discussions, but who had, nevertheless, been rejected, although on account of the qualifications he had mentioned they were well worthy of the desire of the Council that they should be elected to the governing board. As a consequence these gentlemen had lost all interest in the Society, and had not come amongst them again, which was one of the most serious consequences of the process that they had adopted. Another very serious objection was this. Their Society had rapidly increased in numbers, the various fields in which electricity was being applied were rapidly extending, and it was quite evident that if the Council was to properly represent the interests of the Society it ought to mirror fairly and fully the wants and aspirations of each section of practical electricity. There was a very strong evidence of this desire in the correspondence that many of them might have noticed in the technical journals that week, notably in a letter signed "Telegraphist," wherein the writer pointed out that telegraphy, which was the origin of the Society, and whose members formed the largest section of it, but many of whom were scattered over the face of the earth, and therefore could not record their opinions, was consequently left to those few in London who were interested in the science, and who generally recorded their votes. Telegraphy was a very important branch of electrical science, and the Council had selected two of the most prominent and eminent members connected with the profession of telegraph-engineers, men who had held extremely high positions, and who would have been an honour to the Society, and forwarded its interests; but both those gentlemen had declined to appear on the Council list to be subjected to the competition to which he had alluded. There were other powerful reasons against the present system, with which he would not now trouble them; but the principal reason he would urge why they should return to their old practice was, that it was adopted by every other society except that which he had mentioned, viz., the Institution of Civil Engineers, and even there there was brought prominently before the Council last year the very motion he was now going to submit, that instead of presenting for selection a more numerous list of names than would form the Council, they should look upon the Council as the directors of a company who, if they neglected their duties, might be turned out at the end of the year. Therefore, he could not see why they should continue the practice, which had about it the very objectionable features that he had named, and he begged to propose that the Council revert to the old practice of submitting for election a complete list of the Council.

The PRESIDENT: By a complete list of the Council, you mean a list consisting of no more names than those who are to be elected?

Mr. PREECE: Exactly so.

Prof. FORBES seconded the motion, observing that Mr. Preece had adduced very forcible arguments indeed in favour of his contention, and he (the speaker) felt assured that everyone would appreciate them. The subject was brought before the Council at a recent meeting, and the cogency of Mr. Preece's views was then seen to be very strong. In consideration of a very general expression of opinion among the members, they had moved in the other direction a few years ago, and if the Council determined to revert to the ancient system the members ought to know what were the reasons that led many of the Council to think that the old plan was the best. He felt sure that the sense of the general body of the members would be favourable to Mr. Preece's proposal, and that they would see how undesirable it was that any unpleasant feeling should be aroused in consequence of the names of eminent men being put forward as councillors, and who might ultimately be rejected. He had great pleasure in seconding the motion.

Mr. H. C. DONOVAN considered that the old system of naming the exact number of candidates had created great dissatisfaction, because the majority of the members simply folded up the ballot papers and sent them back, without paying the least attention as to who were proposed for election. What was wanted was a number of names to select from, and if the Council could give some idea of the position of the gentlemen whom they nominated—their history, or something of that sort—it would be a distinct advantage (applause). There were numerous gentlemen on the Council whom he did not know—they might be telegraphists or electricians, but he did not know which. If a circular were issued, asking the members to recommend their candidates, then, he thought, the Council would be able to do better than they had done hitherto, though, as it was, they had done very well.

Mr. H. NEWMAN LAWRENCE said, as a humble member of the Associate class, he should like to say a word on this vexed question of the election of the Council, in which he was disposed rather to agree with the last speaker. Not the least of the difficulties to be overcome was the apathy of the members, who were rather given to criticism, and who generally shirked the responsibility of doing work themselves. No doubt there was great difficulty in both systems in getting at the exact wish of the great body of members, and although he was not prepared to oppose the motion of Mr. Preece in any way, he suggested whether it would not be possible, in reverting to the old system, to invite the members some time before the election to specially nominate certain persons whom they might think worthy of the honour of being selected by the Council as candidates for the votes of the Society. That might enable individual members to express their opinions in regard to any particular men or section of men, and perhaps to bring into deserved prominence men who were not likely to be otherwise noticed. He had heard from Mr. Preece with much regret that several of the most eminent members of the Society were so remarkably thin-skinned on the subject of selection (applause). He thought that anyone who was willing to accept a position in a society of that kind ought at least not to object to stand a contested election.

Dr. LANT CARPENTER said there was one point on which he wished a more precise statement for the information of some of the younger members. When Mr. Preece said that the Council should submit a complete list of names, he presumed that liberty would be allowed to members to erase any individual name and to substitute another. He raised this point because he thought it was extremely important.

Mr. PREECE stated that at the suggestion of the Secretary he proposed to word his resolution in this way, "That in future the list of members and associates proposed by the Council for election on the Council be limited in number to the number of vacancies to be filled." In answer to Dr. Lant Carpenter he would say that he did not propose to make the slightest change in the form or mode in which the election was made. At the present time everybody was at liberty to erase any name and substitute another, and that was a most necessary check to be maintained. Perhaps, if the suggestion of a circular being issued a month or two before the election asking the members to submit names were carried out the difficulty might be met, but that practice had not been in vogue in other societies. Personally, he should like to see the Council more varied than it was at present, as there was nothing so good for the Institute or for its members than that the latter should pass through the Council and see how the work of the Society was carried on, and the great zeal and regard for its interests which the members of the Council invariably exhibited. Mr. Laurence had said something about people being thin-skinned. Well, he thought it was human nature to be so. Until defeat was met with they all thought themselves to be cock of the walk, and when they were sent away with their tail between their legs they did not like it (laughter). However, whether they were thick-skinned or thin-skinned, if they could promote the interests of the Society without hurting the feelings of one of its members he thought they would have done a very good thing.

Mr. DONOVAN considered that the last suggestion would throw a very invidious task on the Council, as, owing to the apathy of the majority of members and associates, the Council's nominations would, in all cases, be elected, thus making the Council practically a self-elected body, which would, in his opinion, lead to much dissatisfaction. He thought some means might be adopted by which the voice of the interested should be heard and felt in the selection of members of Council.

Mr. W. T. GLOVER asked if this was a question which they ought to decide without notice. They all recollected the trouble which led to the change in the mode of nomination, and it appeared to him very much better that so important a departure should not be made without due notice being given (applause). Then those members who felt very strongly on the subject—and he knew there were a great many who did so—would have an opportunity of coming forward and recording their votes.

The PRESIDENT thought that some further discussion should take place. He did not know that there was any urgency, and if Mr. Glover was of that opinion he could move an amendment to that effect.

Mr. GLOVER said he would be glad to do so. He certainly thought that the members ought to be given a full opportunity of expressing their views on the subject before reverting to the old practice. He had great pleasure in moving that notice should be given of the motion which was before them.

Prof. FORBES suggested that Mr. Glover's object would be best attained, and the opinion of the whole body more fully elicited, if a circular

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were sent round, so that everybody might see the discussion that had taken place. They would then be in a position to vote intelligently.

Mr. PREECE said that he quite agreed with Prof. Forbes in this regard. He had simply taken the opportunity of ventilating his views, and he deprecated very much their coming to a hasty decision. There was no need for immediate action, as they had eleven months in front of them in which to mature their plans.

Mr. GLOVER said he would withdraw his amendment if Mr. Preece would act upon his suggestion.

Mr. PREECE said he would make the addition to his proposition.

The SECRETARY suggested that the circular should only be sent to members in the United Kingdom. In this way he thought the general opinion of the members would be arrived at, whilst their decision on the question would be more quickly known than if they had to await the replies from Japan, New Zealand, and Kamschatka.

Prof. FORBES thought that would not be quite fair to the large class of telegraphists whose claims Mr. Preece had advocated.

Mr. PITMAN, as a member of the absentee class, demurred on behalf of his brother members in India to the Secretary's proposition.

The PRESIDENT hoped that Mr. Preece would cast his resolution into its final form (laughter).

Mr. MORDEY suggested that it was not quite desirable that Mr. Preece's statement of his views should be put forward alone for members to form an opinion. Mr. Preece very ably expressed one view, but if notice had been given it was probable that a strong expression of an opposite view might have been heard. He thought the circular to be issued should state bare facts, and leave the members to form their own opinion on the subject.

Mr. PREECE said that perhaps Mr. Mordey would give the other side. [Mr. Mordey made no response.] If they liked he would make another proposal, and in this form, that the Council issue a circular to the general members of the Society, asking them for their opinion on this question, and merely stating the facts, without putting it on the strong partisan grounds that he had done.

Mr. GLOVER: Then I have great pleasure in seconding that.

Prof. FORBES said his point would be quite met by what had happened. The reason why he did not wish the Council to decide the matter off-hand was that he felt that if the reasons were put before the members generally they would see that they were cogent reasons. He supposed some account of their proceedings would go forth to the world, and the general body of members would then know the motives that prompted Mr. Preece to take his present line of action.

The PRESIDENT then put the resolution as last amended, and it was unanimously agreed to.

The PRESIDENT having announced the result of the ballot as it appeared in last week's *Electrician*, the meeting adjourned until the 10th January, 1889.

[*A Correction.*—The name of Captain Wrottesley, who was elected as one of the Associate Members of Council, was printed in our last issue as Captain A. S. Wrottesley, R.N.; it should have been Captain A. E. Wrottesley, R.E.]

THE TRANSITION FROM METALLIC TO ELECTROLYTIC CONDUCTION.

The following interesting remarks form the concluding paragraphs of an important Paper by Mr. C. Barus on "Certain Generic Electrical Relations of the Alloys of Platinum" will be found in the December number of the American *Journal of Science*:—

"Taking the results collectively, they point to a limit below which, in the case of solid metals and at ordinary temperatures, neither electrical conductivity nor temperature-coefficient can be reduced; whence it appears that a lower limit of both conductivity and temperature-coefficient is among the conditions of metallic condition, not to say of metallic state.* These considerations are suggestive, and I shall therefore endeavour to make what I have in mind clearer. In the case of conduction in metals (solid or liquid) the effect of temperature is a decided decrease of conductivity, continuing apparently, as temperature increases, indefinitely.† In the case of conduction in non-metallic elements‡ or in electrolytes (solid or liquid), on the other hand, the effect of temperature is a decided increase of conductivity, which supposing the liquid state to be retained, continues as temperature increases. Hence conduction in metals is distinguished from conduction in electrolytes in this respect, that if the temperature coefficient in the one case (electrolytes) be regarded positive, its value in the other case (metals) must be negative. This leads me to inquire into the possible occurrence or the nature of a class of substances whose temperature-coefficient is zero; a class of substances, in other words, in which the metallic and the electrolytic modes of electric conduction may be supposed to converge.*

The point which I have in view, viz., the possibility of a continuous transition from metallic to electrolytic conductivity gains much in reasonableness by associating with good metallic conductivity the correlative property of optic opacity. Relations between electricity and light have been investigated, and many experimental facts are known. Maxwell's electro-magnectic theory of light furnishes a theoretical basis for the fact that, true conductors are exceedingly opaque. The resistance of solid metals, however intensely they may be heated, is found to increase so long as temperature increases. Nevertheless the careful experiments which Govi† made to interpret an erroneous result of Secchi‡ prove that solid metals even in extreme states of white heat remain opaque. In the case of liquid metals at extreme white heat the case is not so definitely established; and the question relative to the ultimate transparency of liquid metals at very high temperatures is an open one.§ It is in the direction of ultimate transparency that the observed continuous increase of resistance with temperature seems definitely to point.

It is reasonable to infer that the transition from opaque to transparent‖ will take place in the region of the critical temperature. At least such transition must ultimately occur; and I am led to conjecture that the said transition from opaque to transparent will be accompanied by a change of the values of the electrical temperature-coefficient, passing from the negative value which holds for the liquid metal, to the positive value which will probably hold for the gaseous metal, continuously through zero. The fact that conduction in gases is of an electrolytic nature was proved by Varley,¶ who showed that after the polarisation of the electrodes is overcome, gases obey Ohm's law. The electric *strength* of air is known to diminish rapidly as temperature is increased. Working with hot gases carefully insulated and protected from flames, Maxwell** was unable to obtain conduction either in hot gases like air or in hot metallic vapour like Hg or Na. At higher temperatures (red heat) the researches of Blondlot,†† confirming the observations of E. Becquerel,‡‡ prove that hot gases are conductors, and that at temperatures sufficiently high $\frac{1}{1000}$ volt is enough to set up a current. Hence in their thermal relations also gases ultimately partake of the nature of an electrolyte, and the occurrence zero value of the temperature coefficient may be reasonably associated with the critical temperature of the metallic liquid, passing continuously from the liquid into the gaseous state.

* Recent researches of *v.* Ettingshausen and Nernst and of C. L. Weber (Wied. *Ann.*, XXXIV., p. 582, 1888), show that the resistance temperature-coefficient of bismuth is often negative between 0° and 100°. Edward Weston has made alloys of copper, ferro-manganese and nickel of which this temperature-coefficient is nearly zero or even negative (*Science*, XII., p. 56, 1888). These exceptions, the underlying cause of which is probably secondary, and to be referred to structural or crystalline modification, emphasise the vast amount of evidence in favour of the normal behaviour given in the text. I may add, for instance, that the temperature-coefficient of glasshard steel between 0° and 100° would be nearly zero, because of annealing.

† Following Benoit (*C. R.*, LXXVI., p. 342, 1873) the electrical resistance of all metals increases with temperature at an accelerated rate, except in the case of platinum and palladium, where the rate of increase is retarded. Benoit observes at temperatures limited by the boiling point of zinc.

‡ Matthiessen (Pogg. *Ann.*, CIII., p. 428, 1858), W. Siemens (Wied. *Ann.* X., p. 560, 1880), and others (Bergmann, Kemlein, Muraoka) find this to hold for modifications of carbon. Similar increases of conductivity are usually observed in the case of selenium and tellurium (Hittorf. W. Siemens, Matthiessen, and many others); but the relations here are complicated. Quite recently Duter (*C. R.*, March 19th, 1888) has shown that sulphur conducts at its boiling point. It is this investigation which I have specially in mind in the text.

* Something of the kind may perhaps occur in the case of some natural sulphides, but it is not open for systematic study, and its nature is obscure.

† Govi, *Comptes Rendus*, LXXXV., p. 699, 1877.

‡ Secchi, *Comptes Rendus*, LXIV., p. 778, 1867.

§ W. Ramsay, *Chem. News*, LV., pp. 104 and 175, 1887; Turner, *ibid.*, p. 163, 1887; Prof. T. Sterry Hunt has given the question some attention. Kundt's recent experiments (Wied. *Ann.*, XXXIV., p. 469, 1888), on the refractive index of metals will doubtless lead to more definite results than the data now in hand.

‖ The jet of liquid hydrogen escaping from Pictet's apparatus appeared steel-blue, and was opaque for a distance of about 12 centimetres.

¶ Varley, *Proc. Roy. Soc.*, XIX., p. 236, 1871.

** Maxwell, "Elementary Treatise on Electricity," ed. by Garnett, 1881, §§138, 139.

†† Blondlot, *Comptes Rendus*, XCII., p. 870, 1888; *ibid.*, CIV., p. 283, 1887.

‡‡ E. Becquerel, *Comptes Rendus*, LV., p. 1,097, 1867.

BOOKS, &c., RECEIVED.

"Practical Electrical Measurement." By J. SWINBURNE. (London: H. Alabaster, Gatehouse and Co.)

"Programme of the City and Guilds of London Central Institution for the Session 1888-9."

"*Proceedings* of the Academy of Natural Sciences of Philadelphia." Part II., March-September, 1888. (Philadelphia.)

"Taschenbuch für Monteure Elektrischer Beuleuchtungsanlagen." By S. FREIHERR VON GAISBERG. Third edition; enlarged and revised. (Munich and Leipzig: R. Oldenbourg.)

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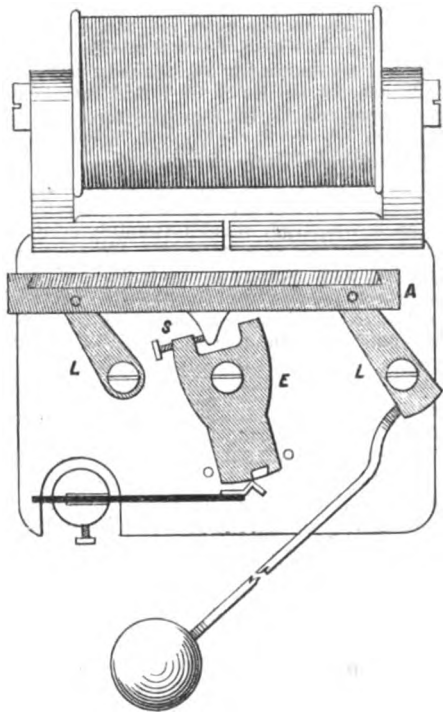
SNELGROVE'S ELECTRIC BELL.

Messrs. W. and T. Avery are introducing an electric bell designed by Mr. Snelgrove, which differs in several important details from the ordinary designs. As will be seen from the figure, the poles of the magnet are bent round so as to form an almost closed magnetic circuit; while the armature A, when vertically attracted by the magnet, is constrained by the links L L to move in a horizontal direction, striking as it travels against the upper jaw of the oscillating switch E and breaking the circuit, this horizontal movement being also utilised to strike the bell. There are several advantages gained by this arrangement. Owing to the almost closed magnetic circuit, and the approximately parallel travel of the armature (which even at its most distant point is comparatively close to the magnet), a weaker current can be used than is usually possible. Additional power is also obtained owing to the fact that the electric circuit is not broken until the moment before the hammer strikes the bell, thus producing a more powerful effect, with equal battery power, than is obtained from the ordinary "trembler." Snelgrove's bell can be used either as a continuously ringing bell,



A, Armature. LL, Links. E, Oscillating Switch. S, Adjusting screw for varying length and duration of stroke. D, Insulated contact post, with contact spring tipped with platinum, bearing against E.

or by simply connecting up to the third terminal screw it will work as a single-stroke bell; one bell can, therefore, if desired, serve two distinct rooms, one ringing single and the other continuous strokes.

BARCELONA INTERNATIONAL EXHIBITION.

The following awards have been made in the Electrical Section of the Barcelona International Exhibition:—

GOLD MEDAL.

Anglo-American Brush Company (London)	Magic fountain.
Bonnet, Enrique (Spain)	Electro-magnetic receptors.
Belleville, J., and Co. (St. Denis, France)	Steam boilers for electric light engines.
Babcock and Co. (New York)	Tubular boilers for electric light engines.
Bertran Rubio (Barcelona)	Electro-medical apparatus.
Ganz and Co. (Buda Pest, Hungary)	Dynamos.
Mildé Sons and Co. (Paris)	Micro-telephonic apparatus.
India Rubber and Gutta Percha Company Telegraph Works (Persan Beaumont, France)	Cables for electric light and other purposes.
Société Générale de Telephones (Paris)	Micro-telephonic apparatus.
Saxby and Farmer (London)	Electric apparatus connected with the block system signalling for railways.
Sociedad Española de Electricidad (Barcelona)	Electric light apparatus.
Fuisseaux, De (Bandow, Belgium)	Porcelain insulators for electric purposes.
Weyher and Richmond (Paris)	Steam engines for electric lighting.

SILVER MEDAL.

Cabeza de Vaca, Francisco (Spain)	A nemascope.
Conradt and Co. (Nuremberg)	Carbons for electric light and other purposes.
Corominas, Ramon (Barcelona)	Electro-medical apparatus.
Charlesworth, S., & Co. (Oldham)	Dynamo.
Galante, José (Spain)	Manual on electricity.
Mayer and Meltzer (London)	Electro-medical apparatus.
Orduña, Carlos (Spain)	Duplex system.
Perez Blanca, Francisco (Spain)	Treatise and manual of telegraphy.
Perez Santano, Miguel (Spain)	Duplex system.
Planas Flaquer and Co. (Spain)	Dynamos.
Gallé, Richard (Berlin)	Electro-medical apparatus.
Suárez, Saavedra (Barcelona)	Treatise on telegraphy duplex system.
Tomasino, Pablo (Barcelona)	Lightning protectors.

BRONZE MEDAL.

Garcia Montalban, Abelardo (Spain)	Double manipulator, &c., for stations.
Hediger, Ruiz (Mahon, Spain)	Electric batteries.
Neville and Co. (Liverpool)	Arc lamps.
Chimkewitch, Peter (St. Petersburg)	Modifications in telephones.
Nicholson, Mambray Steel Works (Sheffield)	Dynamo and lamps.
Piedras, Victor (Spain)	Electric apparatus for intermediate stations.
Spagnoletti and Sons	Electric fire alarms.
Stöker and Co. (Leipzig)	Telephonic apparatus.
Schukert, S. (Nuremberg)	Dynamo and electric lamps.
Schilling, Ermanno (Barcelona)	Electrometer.
Vigil, Primitivo (Spain)	Apparatus for testing strain, torsion, &c., of wire and metals applied to telegraph material.
Vilafranca, Pablo (Barcelona)	Copper and bronze wire for telegraphic and telephonic uses.

HONOURABLE MENTION.

Actien Gesellschaft, Seel and Co. (Berlin)	Electric lamps.
Bons, José (Barcelona)	Points for lightning protectors.
Fernandez Arias, Gregorio (Spain)	Electric apparatus applied to telegraphy.
Ibañez, Alonso Joaquin (Madrid)	Electric commutator.
Loiseau and Pierrard (Paris)	Electric apparatus.
Rey and Villanueva (Spain)	Manipulator for intermediate telegraph stations.
Ruiz and Verd, Pablo (Mahon)	Hydro-electric battery.
Rodriquez, Manuel (Spain)	Points for lightning protectors.
Spiecker and Co. (Cologne)	Dynamo and automatic regulator.
Villahermosa (Spain)	Electric apparatus for intermediate telegraph stations.

A DIPLOMA OF HONOUR has also been given to the Spanish Administration of Posts and Telegraphs for their exhibit of past and present telegraphic apparatus and material. Only the exhibits of Governments are entitled to Diplomas in this Exhibition.

LEGAL INTELLIGENCE.

Edison and Swan Electric Light Company v. Holland and Others.

MONDAY, DECEMBER 10.

Mr. FINLAY resumed the argument by commenting on a judgment in a previous action delivered by Lords Justices Fry and Bowen. The learned counsel read an extract from the judgment of Lords Justices Fry and Bowen in the Woodhouse and Rawson case, as follows:—"As far as we have learnt there are only two specimens of the earlier form of the instrument, and in both these a rod and not a filament of carbon has been adopted. Mr. Edison used it for a definite purpose, and by a diminution of a sectional area made a subsidiary law which carried out the end in view, and so converted failure into success." The learned counsel remarked that the evidence was very different indeed in the present case from what the evidence would have proved in the former case.

LORD JUSTICE BOWEN: In the former case it was distinctly admitted by the defendants that the patent was intelligible for any ordinary workmen to make a lamp that would burn. It was not an assumption; it was the result of evidence so strong as to be admitted by the defendants' counsel as incontrovertible.

Mr. FINLAY: But what I said just now was directed to the principle. In the former case the observation I made was in this passage:—"Mr. Edison used the filament for a definite purpose, and made a subsidiary law subserve the end he had in view. Your lordship now knows that so far as the success of the lamp goes it succeeded perfectly well with a rod, as in F I B 1.

Sir RICHARD WEBSTER: That is your statement.

Mr. FINLAY went on to say: The majority of the Court shows that they laid great stress in that case upon two things, both of which were presented in a very different aspect by the evidence in the present case. The first is that they regard Edison as the discoverer of the idea that by taking a small sectional area in the carbon conductor a physical law may

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be made to yield results valuable in the way of incandescent lighting, as regards not merely the combination for the purpose of multiple arc lighting, but as regards the individual lamp itself. In the second place they assume that there was a great outburst of incandescent lighting following upon Edison's lamp of 1879. I do not desire to repeat what was said by Sir Horace Davey on this point, but there is a mass of evidence now before the Court, which was not before the Court in the previous case at all, as to the state of knowledge among those concerned in these matters before 1879, and I think it is now established that it was common knowledge that the reduction of the sectional area of the carbon conductor would be of great use for the purpose of incandescent lighting. It was not, of course, common knowledge that it would be useful so far as the individual lamp is concerned, because the reduction of the size of the carbon conductor is rather a disadvantage, because it reduces the light of the lamp; but it was perfectly well known to every electrician, and it was proved both by the witnesses for the plaintiff and defendant that this reduction of the sectional area of the carbon conductor as a desideratum was perfectly well known, so that the first point which the Court assumed on the previous occasion is, I submit, entirely gone. On the second head I would point out that there is an assumption embodied in one passage of their lordships' judgment, which I shall read—"The importance of this combination can hardly be doubted, for it has had this result afterwards. Before November, 1879, two or three experimental lamps were all that had been produced; after that date such lamps had been produced by tens of thousands, and constituted a most important element in other methods of electric lighting." Though not directly stated, the assumption of that statement is that shortly after November, 1879, there took place in consequence of this invention of Edison an outburst of activity. I venture to dispute that, and I shall proceed to show that there is not even a coincidence in the so-called outburst of electric lighting, as suggested by Mr. Aston. In order to do that I shall draw attention to the stages of this invention in the way of electric lamps in 1879, 1880, 1881, and 1882. The patent now in question was the 10th November, 1879. On the 15th December, 1879, Mr. Edson took out the cardboard patent. Then, on the 2nd January, 1880, Mr. Swan took out his patent for running on the pumps. Now, let me point out the result of the evidence; it was perfectly well known that in multiple lighting, with the conductor of a small sectional area, there were two difficulties; the first was how to make a carbon conductor, and anyone who could discover a good process for making such carbon conductor would be entitled to take out a patent for it. The other point was the difficulty of securing a perfect vacuum, and that arose in this way—although the use of the Sprengel pump had enabled them to obtain a good vacuum in the first instance, yet, owing to the gases which were occluded in the conductor and in the platinum wires when the lamp afterwards came to be run, those occluded gases were expelled, and you no longer had your perfect vacuum. With both these difficulties Swan deals in two patents taken out in the same month. The first refers to the question of occluded gases.

LORD JUSTICE BOWEN: It is material to know that this invention was made by this time, but I do not see how putting a statement of Mr. Swan's in that he did make it proves it.

LORD JUSTICE LINDLEY: Your object is to prove that the outburst was due to other things.

Mr. FINLAY: In the first instance I wish to prove that the outburst was not until long afterwards, and, in the second place, I am going to show to what it was really due. For my purpose it does not matter whether Mr. Swan is the true inventor of running with pumps or not; but my purpose is to show the real history as to the activity in electric lighting.

LORD JUSTICE LINDLEY: The fact was that there was another improvement.

Mr. FINLAY: Yes.

LORD JUSTICE BOWEN: This patent of Swan's proves no doubt, that from this time it was known after, but it does not prove that it was known before.

Mr. FINLAY: My point is this, that it was about this time that that process came into notice, and I think I can show that. If you turn to Mr. Swan's cross-examination he says the word "filament" was not used in 1879. Then Mr. Swan was asked if he were troubled with smoke in his lamps, and he replied one of the difficulties was the blackening.

LORD JUSTICE COTTON: You are passing by what may be material—the words "filament was not used at that time."

Mr. FINLAY: His answer showing that the words "filament was not used at that time" was a most material answer, which was discussed by Sir Horace Davey as to how far the judgments in the previous case gave any definition of the word "filament" which is binding on your lordships here.

LORD JUSTICE BOWEN: The difference between the two judgments on this point seems to me to come to this, that the majority of the Court take the view that Swan's rod is not a filament, and Lord Justice Cotton seemed to think that if you took the filament in the widest sense Swan's rod might have been a filament; but then he thinks that the word is used not in the wider sense but in the more specific sense, and that by implication it was to be formed before being carbonised. In that case, Swan's rod would not be a filament, as it was not carbonised until after it was made.

Mr. FINLAY: Exactly.

LORD JUSTICE BOWEN: That is what the two views came to; but then we must consider how far we are bound by the judgment of the majority; the judgment of the majority being that the filament being taken on the larger view, Swan's rod was not a filament.

Mr. FINLAY: I submit there is no very clear decision of the Court to that effect, and, if so, it would be a mere matter of fact, which in no way trammels your lordships in dealing with the present appeal.

LORD JUSTICE BOWEN: That may be. We did take the view that it may be a matter of law.

Mr. FINLAY: How can it be a matter of law?

LORD JUSTICE BOWEN: That is a question. How could there be in the "Law Reports" a head note to this effect—"Whereas $\frac{1}{25}$th of an inch in diameter is not a filament, but the $\frac{1}{1000}$th is?" That must be a matter of fact to be determined in every case according to the evidence by the appropriate tribunal.

LORD JUSTICE BOWEN: If it was a fact, all that I say is if that I drew a wrong inference on that fact, I should change my mind.

Mr. FINLAY: Of course where the evidence is different one must necessarily come to different conclusions where the same question arises. All that was decided in the previous case was on the evidence then before the Court. Let us take the illustration of Lord Justice Cotton. If the Court laid down that in a particular Act "horse" included "mare," no doubt so far as that general principle goes the Court would be bound afterwards, but in every case it would be for the jury to decide whether it was a horse or a mare upon the evidence, and if the Court had come to the conclusion that it was a mare it would be at liberty to say that it was a horse.

LORD JUSTICE LINDLEY: Or neither.

Mr. FINLAY: Or neither or both. Now I have been a little turned aside from a point of very great importance, as to the running on the pumps. Mr. Swan was asked if he was troubled with something in his lamps, and he replied, "Yes, one of the difficulties we had to compete with was the blackening of the bulb. The only assistance I received from Mr. Proctor in connection with the blackening of the globes was the investigation of the nature of the deposit of the broken lamp shown at the Chemical Society. I took up a patent in January upon the running of the pumps, and I claim a patent for running on the pumps for the purpose of getting rid of the occluded gases. *Q.* Did you not intend to show that you could produce an incandescent-lamp horse-shoe cardboard conductor?—*A.* An improvement on running on the pumps. I did look upon the improvement of running on the pumps as the greatest barrier in making a satisfactory incandescent lamp, and afterwards I found other difficulties, and I think I was a little premature in saying that I had conquered all the difficulties." I submit that that evidence establishes that during the year 1879 electricians had been bothered (and there is no evidence to the contrary as far as I know) with the occluded gases blackening the lamp, and that Mr. Swan considered that he had discovered the mode of dealing with that, and that he embodied that discovery in his patent on the 2nd January, 1880. This patent describes the process of running on the pumps. It keeps the pump in action while the current passes through the lamp. Then comes Swan's patent of 20th January, 1880, for overcoming the difficulty as regards the manufacture of those carbon filaments. I have submitted that the principle was perfectly well known; that the practical difficulties were two—first, the occluded gases blackening the globe, and secondly, how to manufacture the carbon conductor. The first of these difficulties Swan dealt with on the 2nd January, 1880, and with the second on the 20th January, 1880. On the trial before Mr. Justice Cave, my friends endeavoured to show that this patent of November, 1879, had put Swan on the right track, and that in some way or other he was indebted to it. But that patent was not published until May, 1880, and if your lordships will look at the drawings you will see that Swan had nothing to gain from the patent of Edison with regard to this question of carbon filament.

LORD JUSTICE BOWEN: We recognise the importance of your argument, but we only doubt whether you are proving it in the right way.

Mr. FINLAY: Those two patents of Swan could have had nothing to do with the patent of 1879.

LORD JUSTICE BOWEN: Still, after the running on the pumps, there were two defects. The first was the cracking or leaking of the glass bulb, which he remedied by this platinum. The other one was the practical difficulty of the inner arch of the cardboard, which he remedied by taking a strip, cut straight, instead of in the form of a horseshoe.

Mr. FINLAY: I wish to follow out the history of this matter Edison's patent was December, 1879, his cardboard patent, and Swan's patent for cardboard paper was next. Then in the early part of 1880 Mr. Johnson gave Dr. Fleming six Edison lamps. Then Swan, when being cross-examined by me, said: "*Q.* With regard to those lamps brought over by Mr. Johnson, when was it?—*A.* In the beginning of February, 1880. *Q.* You are familiar with the patent?—*A.* I know the specification generally; it is for making burners out of cardboard." We say that these lamps were made under the cardboard patent of 1879; but your lordships see what they are intending to do. They were running in what was called an installation in February, 1880, and the suggestion was that this was under the patent of 1879. If that were so they had the means of proving it beyond all doubt. They could have proved it by Edison and Johnson, and in many ways if the fact were so. They did not attempt to do it, because the lamps were made under the specification of December, 1879, and we say that we have given by the cross-examination of that gentleman *prima facie* evidence that this was an attempt to show that his lamps were made under the patent of November, 1879, whereas the lamps were made under a patent taken out a month afterwards.

LORD JUSTICE BOWEN: Do you suggest that it is made under the cardboard patent?

Mr. FINLAY: I suggest that they were made together under the cardboard patent. The importance of this point is, when we challenged that any lamp had ever existed under the patent of 1879, except for the purpose of litigation, if my friends could have proved it they certainly would.

LORD JUSTICE COTTON: If your object is to remove the impression produced in the former case that the great start in electric lighting was in consequence of the patent of 1879, I may tell you that I am not impressed by that argument one way or the other. If that is a good patent, although a great start was not made in consequence of it, yet it would be within the patent.

Mr. FINLAY: Really, then, the November, 1879, patent was veiled in obscurity until it was discovered as a patent to run this claim for a monopoly, but for all practical purposes it was brought out into the light

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of day for the purpose of an action against Mr. Swan, and Mr. Swan swore an affidavit that the patent was bad.

LORD JUSTICE BOWEN: Does not that resolve itself into these two points, first you say that the idea of a filament in a larger sense was not obtainable?

Mr. FINLAY: Yes.

LORD JUSTICE BOWEN: And, secondly, that the process given for the manufacture was not workable?

Mr. FINLAY: Yes.

LORD JUSTICE BOWEN: It is only the same argument in a different shape.

Mr. FINLAY: It is illustrating by the evidence of its history what we say is the worth of our argument. His patent of 1879 was brought to bear in 1879, and Mr. Swan swore that the patent was bad, but the two parties formed themselves into a company in which Mr. Swan took the greater part of the shares.

Mr. MOULTON: No.

Mr. FINLAY: That is proved; and the two having combined their forces, they proceeded to attack all other manufactures in detail. But this patent of February, 1879, never had any value except for the purpose of litigation.

LORD JUSTICE LINDLEY: It was never litigated between Edison and Swan.

Mr. FINLAY: There was no decision of the Court at all, but the fact that in the compromise Swan got rather the larger share, shows how that went.

LORD JUSTICE LINDLEY: That we have nothing to do with.

Mr. FINLAY: What I desire to do in the way of tracing the history of the case is this:—On the 16th September, 1880, Mr. Edison took out his bamboo patent. In the late autumn of 1880 Mr. Stearn's house was lit with Swan lamps. On the 24th November, 1880, the Swan lamps were exhibited at the Institute of Civil Engineers, as proved by Prof. Perry. In the same month, in November, 1880, Mr. Swan took out his patent for the use of parchmentised thread; and at the end of 1880 Mr. Swan, as he states, made a considerable number of lamps. With Swan's lamps Mr. Crookes's house was lit up in December, 1880—that is proved by Mr. Crookes and Prof. Frankland. In February, 1881, Mr. Bernstein visited the Edison works in America, at Menlo Park, and the lamps that he found Edison making were the bamboo lamps like E. F. 1. Every lamp that Edison ever sold we say was made under this bamboo patent. In July, 1881, there was an exhibition of Swan lamps at King's College, and that is proved by Mr. Crookes. In August, 1881, there was an exhibition at the British Association of Swan lamps, at the York Meeting, and that was proved by Prof. Thompson and Prof. Perry. In September, 1881, at the Paris Exhibition, there was a display of Swan lamps and the Edison lamps, and that is proved by Mr. Crookes and Prof. Thompson. There was at the Paris Exhibition a great many thousand of Swan lamps, and Prof. Frankland says that there were not so many Edison lamps there. The lamps exhibited at Paris, in September, 1881, were lamps made under the bamboo patent. I will not trouble your lordships by going through the eleven points of difference which were proved by Prof. Thompson, but September 1881, with the exception of that small exhibition of half-a-dozen or so in February 1880, was the first time that the Edison lamp was exhibited in Europe. In 1881 the Savoy Theatre is lit up with the Swan lamps, and that is proved by Prof. Perry. September, 1881, was the first time that Mr. Crookes, Mr. Frankland, Prof. Thompson, Prof. Perry and Mr. Swinburne ever saw an Edison lamp. All these are gentlemen who are certain to have known what was going on in the matter of electric lighting, in which they took great interest. They were skilled, and they saw that it was the bamboo lamp. Then there was an exhibition in the early summer of 1882 at the Crystal Palace. I defy my friends to say that this patent of November, 1879, had anything to do with the bringing into life of that industry in incandescent electric lamps. I defy my friends to point out in the evidence any foundation for that statement which was made in the previous case and which really seemed to a considerable extent to have influenced the minds of some of the Court. I am not at all sure that my friends have not benefited in this litigation by a sort of association in the minds of many between the Edison lamp and the great scare with regard to the value of gas shares which took place in consequence of the supposed invention of Mr. Edison. That took place in 1878, in consequence of Edison's advertisement of the platinum lamp that he had invented.

Mr. MOULTON: It is not fair for my friend to state that.

Mr. FINLAY: I do not see that my friend has any reason for objecting.

LORD JUSTICE COTTON: I do not know that that would influence the Judges of the Court of Appeal—and you are before them now—whatever it might do with any other tribunal.

LORD JUSTICE LINDLEY: Do not go into gas shares.

Mr. FINLAY then referred to the evidence of Mr. Proctor to show the experiments made by Mr. Swan in 1879. The lamps then made were seen by many people at Mr. Swan's works, and they were lamps which burnt fairly well. They were all vacuum lamps, with carbon conductors and platinum leading wires; the carbons would vary in thickness, but thinness was aimed at. He thought they could rely upon the dates given by Mr. Proctor, testing his evidence by the light of Mr. Swan's cross-examination. He submitted that whatever doubt or obscurity there might be with regard to some of the lamps made by Mr. Swan, it was perfectly clear, from his admissions in cross-examination, that before November, 1879, he was making lamps with the little horse-shoe hairpin Carré carbons. He did not, however, know that any cards were used before November, 1879. He wished to call attention to the very odd way in which Mr. Swan gave evidence with regard to the paper; he did not impute the slightest want of good faith, but it was clear that Mr. Swan was mistaken. On Dec. 29, 1879, Mr. Swan wrote to *Nature*, stating that fifteen years before he had used charred paper and cardboard for the construction of incandescent lamps, and that he had used it in the shape of a horseshoe precisely as Mr. Edison did, but that he did not succeed in obtaining the durability he was in search of. He went on to say: "Within the last six months I have, I believe, completely conquered the difficulty which led to previous failure, and I am now able to produce a perfectly durable electric lamp by means of incandescent carbon." That would take one back to the middle of 1879.

In reply to LORD JUSTICE COTTON,

Mr. FINLAY said Mr. Swan had admitted this to be correct, and had suggested that the mode of overcoming the difficulty was the running on the pumps. On the 20th January, 1880, Mr. Swan took out his patent for making the horseshoe conductors, the filaments being shown in a very filamentous form in the drawings annexed to the patent. Mr. Swan having taken out that patent in January, 1880, and having three weeks before written to *Nature*, stating that within the last six months he had overcome the difficulties with regard to the use of horseshoe filaments with charred paper, Mr. Finlay suggested that he must have been mistaken when he said he had not been experimenting with cardboard or working with cardboard or charred paper for the purpose of making these burners since ten or fifteen years before. Mr. Swan did distinctly swear that he never made a lamp with a carbon conductor of thread until the year 1880, and not having been shaken on cross-examination with regard to it, he was entitled to the benefit of having clearly contradicted Mr. Proctor on that point. Mr. Finlay did not, however, think it was suggested that Mr. Swan was in any way led to use thread by the patent of November, 1879. The learned counsel then read the evidence of Mr. Heaviside for the purpose of showing that Mr. Swan at that time owed nothing to Edison's patent of November, 1879. This evidence, coupled with Mr. Swan's admissions, proved that Mr. Swan working in his own lines independently of Edison, before Edison, and after Edison, without knowledge of the patent of November, 1879, was getting a lamp of the kind that was put forward as having made this revolution in electric lighting.

LORD JUSTICE COTTON: The impression upon my mind is that both Swan and Edison were working at the same time and for the same point, but that Edison got out his patent first. Then the question is whether Edison did get out a good patent.

Mr. FINLAY said that relieved him from going any further into detail. He then referred the Court to the evidence given by Mr. Mayfield, Mr. Ridley, and others, who were called to prove that Mr. Swan, in conjunction with Mr. Stearn, was in 1879 making lamps with a carbon filament. He did not think what had happened at Mr. Stearn's would have prevented them from afterwards taking out a patent for what they had done; but the importance of this evidence was that it bore out his statement that Mr. Swan and other electricians working in this country really owed nothing to Mr. Edison's patent of November, 1879. The other side had protested very much against Mr. Justice Kay's application of the doctrine of commercial utility to their lamps, and said that those lamps ought to be judged by some other standard; but if that looser rule availed the other side, it also availed him as regarded F J B 1, which he said was an anticipation. In conclusion, he claimed that the defendants had broken down the specification on the questions of the sufficiency of description and of its utility, upon the three points of carbonisation, tar putty, and pyro-insulation.

At the conclusion of Mr. Finlay's speech the case was again adjourned.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 8th*, 1888.

The announcement has been made during the past week of another absorption by the Western Union Telegraph Company. The lines taken over in this instance are those with which the Atchison, Topeka and Santa Fé Railroad have carried on a commercial business for some time past. There are about 2,000 miles of line involved in the purchase, it is said, together with about 1,500 miles in Texas and the Indian territory. In some quarters surprise is expressed that the Western Union Company should find any lines to absorb at this late day, but the fact is there are still a large number of small companies doing an independent business. Although the individual totals are insignificant, probably the aggregate would not be a small one. In the case of the railroad which is mentioned the commercial telegraph service was very much in the nature of what is known here as a "side show," and there need be no great surprise that the transfer should be made to the Western Union Company. One of the immediate and direct benefits to the public has been a reduction of 25 per cent. in the rates, and the opinion is that the telegraph service at all the points reached will be greatly improved.

While the Western Union Telegraph Company thus maintains its old policy of acquisition, and ever and anon enters into possession of some new territory, exemplifying territorial growth very much in the same way that the British Empire does, on the principle that the only way to protect the present frontier is to establish another one a little beyond it, the

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American Bell Telephone Company very seldom has an opportunity to buy out a rival or competitor. Its opponents long ago said that it owned the earth and wanted the water too. This was, after all, a jealous acknowledgment of the fact that the Bell patents covered the whole practical field of telephony, and have been rigidly enforced in every instance, so that no competitor has ever been allowed to make any great headway. Since the day when the Western Union Company went out of the business and agreed to take 20 per cent. of the gross earnings of the American Bell Telephone Company as a reward for sitting still and doing nothing, almost all the opposition companies of which we have heard so much have been largely on paper. There have been a number of Baxter, Wallace, Clay, Pan-electric, and other instruments in use from time to time, but the aggregate was always very minute, and the effect of the use of these infringing instruments has in each case been purely local. And these facts give more prominence than it would otherwise receive to the fact that the American Bell Telephone Company has just purchased the entire plant of the Superior Telephone Company of Wisconsin for $35,000. Under some circumstances this might mean a great deal, but the simple explanation is that the Superior Company has a plant of poles, line, &c., which had a market value, and which it was cheaper to buy than to replace. So far from feeling any weakness in the matter, the American Bell Telephone Company has been rendered invincible in that quarter by the perpetual injunction which has just been issued by the United States Court at Chicago restraining the infringing Inter-State Telephone Company from any further operation whatsoever.

One of our papers here has lately devoted itself to a systematic attack upon the work of the Board of Electrical Control. One of its reporters states this week that he watched the laying of the iron pipes in subways in Twenty-fourth and Twenty-fifth streets a few days ago, and that the iron tubes which are used were in actual contact when the asphalte cement was poured over them, although the very object of the cement is to keep these pipes apart. He further asserts that when the manholes of the conduit on Sixth-avenue were opened for the purpose of making repairs they were frequently found full of water, and had to be pumped out before the workmen could get down to the ducts through which the cables ran. So common has it become to find the manholes full of water, he says, that a suction pump is now an essential part of the kit carried by the Construction Company with their waggon. Hence, with water and gas, and iron tubes which lie together instead of widely apart, the conduits are allowed to be in very bad shape, and this is instanced as a good reason why the local lighting companies should not be driven into them. The reporter winds up by saying, "It is not at all remarkable that the various companies operating the lights should decline to place their conductors in conduits which both experiment and common sense have shown will not meet their requirements. Those who have tried them will not do so again, and those who have not will not." While these newspaper articles are not to be accepted as the best evidence in dealing with so complicated a question as that of putting the wires underground, their appearance is an indication of the bitterness of the struggle which is now going on. In our neighbouring city of Brooklyn matters between the Subway Commissioners and the various electric companies appear to be in a more harmonious state. This arises partly from the fact that the Commissioners have not been very urgent in their demands for the burial of the wires, and because they have given the companies a great deal of latitude as to the systems to be laid down and experimented with. An important piece of work has just been finished by the New York and Brooklyn Telephone Company, which has laid a number of conductors underground, using the Brooks oil system, with which, probably, your readers are familiar, the main idea being to saturate the textile cover of the cables with a mixture of resin and resin oil, and then to draw the cables into the wrought-iron pipes, into which, after the cables have been pulled in and spliced, a quantity of the same mixture is poured until no more can be introduced. Good results have been obtained with this system in telephone work in New York and Philadelphia, and it is believed that success will also be enjoyed in Brooklyn.

Mr. W. McGrath, the superintendent of the local Brush Company, is reported to have said to one of the New York Subway Commissioners that the growth of electric lighting in this city during the present year has been no less than 200 per cent. This may seem an exaggeration, but to those of us who witness the tremendous growth that goes on it does not seem very much out of the way. Not only is there a steady and large increase in the number of street lights in the old districts, but in the suburbs new circuits are put up every day, and this is supplemented by a brisk demand for lights in front of stores, hotels, theatres, and such places. But the chief growth occurs in connection with incandescent lighting. A large number of these lights are supplied from the street circuits, but it is becoming the practice for every large new building to have its own plant, and in order to render some older buildings more attractive, incandescent plants are being put in. At the present time the increase in the number of isolated plants is really very remarkable, but it remains to be seen whether the starting up of the large new central stations will not put a check upon that part of the work. Up town, for example, where the new Edison stations are about ready to go into operation, it may be taken for granted that some of the proprietors of the places where isolated plants are being installed will find it more convenient to take their current from the street mains, though, as I have said, just how far this will be done is uncertain. These places—hotels, theatres, &c.—with a large number of lights, ranging from 500 to 2,000, prove good customers for the central stations, and tempting inducement would be offered them.

It is reported from Chicago that Prof. Elisha Gray is about putting the finishing touches to his telautograph system, which was recently described in the technical papers. It is claimed that the reproduction made by the instrument is just up to the point of not being the original. The difference is enough to prevent long-distance forgeries, and at the same time the copy at the other end is so nearly like that which is written at the sending end that, for all ordinary purposes, it is the same handwriting. It is intended, of course, to put the new system in competition with the telephone, but perhaps there will be more limitations to its employment than are now supposed. If it be anything like what it is said to be, there will be nothing to prevent our special artists at the seat of war, or any other seat, from sending in an illustrated account of what is going on. In this way the reader of the daily paper will not be dependent upon his imagination for the description given in the letter, but he will be able to gather from the sketches just how things happened. This will be quite a development of journalism; but it will not hold a candle to the journalistic enterprise with which Mr. Edison is credited, namely, the issuance of a talking daily newspaper. The idea of this appears to be to charge the record cylinder with a condensation of the news of the day, so that each subscriber can listen to the instrument while at breakfast, and will not be under the painful necessity of borrowing first the sugar bowl, then the milk jug, the coffee pot, or the toast rack to prop up his paper with. If a new opera has been produced the night before, he can listen to an able but concise criticism of it, and enjoy with his family the sensation of having repeated the choicest passages of the music just as they were rendered at the theatre by the *prima donna* or the "star" tenor. These various suggestions and promises leave one very much in doubt as to what the newspaper of the future will be like.

Two very important circulars have been issued by the Westinghouse Electric Company, under the date of December 1st, with regard to the contracts and arrangements heretofore existing between them and the Thomson-Houston Company. It is announced that the limited license accorded to the Thomson Houston Company to make alternating apparatus under the Westinghouse patents has been terminated, and that so far as those patents have any scope or validity, the manufacture of such apparatus by anybody but the Westinghouse people themselves will be an infringement. It is stated, moreover, that the Westinghouse patents cover not only what is known as the ordinary alternating system, but the fundamental principle of what is called the Thomson compensating system,

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which has lately been introduced with success by the Thomson-Houston Company. The circular takes cognisance of the fact that an arrangement now exists between the Thomson-Houston and the Fort Wayne Jenney Companies with regard to the use of the alternating system, and that the latter company is controlled by the former. The second circular referred to states that the Westinghouse Company, as licensees of the Consolidated and Sawyer-Man Companies, have entered into a new contract with the Thomson-Houston Company, to take effect from the beginning of the present month, whereby all previous contracts have been cancelled, and a new license has been granted to the latter company to manufacture and sell lamps under the Sawyer-Man patents, but only for use in generating apparatus made by the Thomson-Houston Company. The practical meaning of this is that so far as the Thomson-Houston Company use the Sawyer-Man lamps, they can only do so in connection with the arc circuits and direct continuous-current incandescent lighting. It will be gathered, too, from the above, that the alliance between these two great companies, which at one time pointed so strongly to an even more general unification of competing interests, has been broken, and that, if anything, the rupture may become greater than it is now. The Westinghouse Company take occasion in this circular to point out that the development of the alternating system in the United States is almost wholly their work, and that they are entitled to the benefit of it, and that, on the other hand, the claims of the Fort Wayne Jenney Company to do an alternating business are mere pretensions and without foundation. Altogether the situation is an interesting one.

In my last letter I made some reference to the public trial of the Daft electric motor, "Ben Franklin" on the Ninth Avenue elevated road. This week the trip has been repeated with even greater success, the cars being filled with a large number of spectators who were kept away by the dismal weather on the previous occasion. It is stated that next week the "Ben Franklin" will draw a shuttle train regularly over the portion of the road upon which the experimental runs have been made (from Fourteenth to Fiftieth-street), and that the public will have the opportunity to make their journey for that distance by means of electricity. If this be true it will be a most important step in advance, for the feeling of the public towards electric motors is very cordial, on account of its many advantages, and the desire for an opportunity to ride behind them is freely expressed.

CORRESPONDENCE.

MAGNETISM OF STEEL NEEDLES BY LEYDEN JAR DISCHARGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of October 5th, page 711, you printed for me a letter from Prof. Ewing, giving an ingenious explanation of the magnetisation of steel by the oscillatory current of a condenser discharge, as being due to a gradually lengthening period. You also printed a note from me pointing out that if the resistance of the spark gradually increased as the energy of the discharge died down, a gradually increasing period would be accounted for.

So far there is nothing to correct; but I went on to say that Feddersen had actually observed a gradually increasing period in the oscillations when he examined them in a rotating mirror. This statement Mr. R. E. Baynes, of Christ Church, Oxford, has been good enough to correct in a note to me, saying that according to his recollection of Feddersen's experiments the lengthening-out periods were obtained, not in the true vibrational spark, but in the intermittent spark which is often obtained when the resistance of the circuit is much too great for oscillation—such intermittence as degenerates into intermittent spitting when a piece of wood or something of that kind is included in the circuit. On referring to the original Papers of Feddersen I find Mr. Baynes' recollection precisely confirmed; consequently, I was wrong in saying that gradually lengthening periods of vibration have actually been experimentally observed.

Since then I have made a very large number of experiments on the magnetisation of steel needles, with the result that, without saying anything against their being magnetised reversedly in concentric layers, I have lost all faith in the direction of their *resultant* magnetisation being ever abnormal or different from what the direction of the discharge current would lead one to expect; in other words, I believe at present that what occupies so large a place in books as "abnormal magnetisation" has no existence. If this faith, or want of faith, should be justified by further experience, it will become a most puzzling thing to account for the mass of experimental material by which the facts of abnormal magnetism have been substantiated.—Yours, &c.,

OLIVER J. LODGE.

ELECTRICAL THEORY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I find that I have never replied to a question addressed to me in Prof. Silvanus Thompson's letter in your issue of November 16th, p. 54.

I have always meant by "displacement current" true variation of electrical displacement, and not a bodily conveyance of electricity. At the same time, displacement currents necessarily accompany the transfer of electric charges, and also every case of electrical flow in a so-called "unclosed" circuit; and the question is whether the magnetic effect admittedly caused both by conduction and convection currents is wholly caused by them alone in every case, or whether the variations of electric displacement contribute their share to the general effect.

That convection currents are as effective as conduction currents in producing a magnetic field is proved to my mind by the electro-magnetic effects of currents in electrolytes, as well by such experiments as that of Rowland. So far as I know no doubt has been expressed on this head.

But consider a stationary charged sphere suddenly connected to earth, the previously displaced electricity moves in radially in all directions without any whirl of any kind, perfectly symmetrical all round, except where the line of current occurs and disturbs the uniformity.

Now, in such a case as this, there is a conduction current along the wire to earth (or it might be a convection current, if connection were effected by a number of pith-ball-carriers instead of by a wire), and this line of current will admittedly have a magnetic effect; but is that the whole of the effect, or must the variations of displacement be taken into account in order to calculate the whole?

In all cases where electric displacement varies there must be a current of some kind somewhere flowing in an unclosed circuit. The question seems to be whether this current is precisely competent to produce all the magnetic effects observable, and no more.

Before the Bath meeting, I should have confidently given as my impression of the correct procedure (of course derived from Maxwell): Take *all* the currents into account, displacement currents just as much as any others. All are equally effective, and no such thing as an unclosed circuit has ever to be considered for any purpose whatever. Since the Bath meeting, I have not had time to go into the matter afresh, nor to give any real thought to it, and though my impression remains the same, it would be both useless and unseemly to express it without a great deal more consideration.—Yours, &c.,

OLIVER J. LODGE.

ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your article on electric tramcar batteries, motors, &c., has decided us to send you herewith a plate from the car which has been running in Birmingham, and we do this to call your attention to its construction. We note your description of the plate of Mr. Reckenzaun, and also send you a plate of Dr. Frankland's, which we think has exactly the same qualities as portrayed in the Reckenzaun one. You will find the plate sent by us is cast from an ordinary chill, with a bevel in each direction from the centre to the outside, then treated mechanically to flange over the outer edges of the plate, thus forming a means of holding the paste firmly in the plate. We think you

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will see the great advantages of this plate, as in accumulators for tramcar purposes the desideratum is to obtain the greatest possible discharge from a given weight of plates, the area of the active material being an important factor to this end. In the early Julien grids, as tried by Huber, of Hamburg (in whose experiments we were interested, as supplying him with motors, and other material, and also with Julien himself upon the Brussels Tramway, where we have supplied material, and still have orders on hand), the trouble was in the paste falling out of the grids, due to vibration, and the washing of the liquid in the cells, caused by the motion of the car. The oxidation of the grid does not become a factor, as the life of the battery, due to the previously-mentioned causes, is too short for oxidation to have any great effect. The hardened grids, as suggested in your article, due to Julien, we have also made from an early date, probably from as early a date as Julien himself, as we were casting these when he visited us, with a view to getting us to adopt mercury. We did not consider mercury an advantage, but as dangerous to our workpeople, and we venture to state our belief that it is not used in the casting of grids at the present time for this purpose.

We also note in your article that two motors are used upon the Reckenzaun car. In watching numerous experiments we have found that this has a great tendency for the cars to leave the rails, also that small electrical motors have not been found to have the efficiency obtainable from larger sizes, and they have double the liability to derangement. The mechanical mode of driving in this car will not commend itself to mechanical engineers, as the power consumed by this arrangement must be much greater than with simple gearing. The method of charging the field connections so as to be able to run with a varying field in the motor seems an ingenious contrivance for emptying the batteries without obtaining the energy in the form of work upon the car.—Yours, &c.,

For ELWELL-PARKER (LIMITED),
T. PARKER, Director.

Wolverhampton, December 18, 1888.

[We have received the plate referred to, and find that the construction of Dr. Frankland's plate entirely agrees with Mr. Parker's description, but it differs from the Reckenzaun plate in that the grid is of greater thickness; in fact, while the Reckenzaun plate has a thickness of only $\frac{1}{8}$in., Dr. Frankland's is a full $\frac{1}{4}$in. But the paste cylinders in the Reckenzaun plate are $\frac{3}{16}$in. in thickness, and project from the surface on both sides. In the Frankland plate, on the contrary, the paste is flush with the surface. The latter plate, owing to its thickness, is, of course, perfectly rigid, while the Reckenzaun plate, as we noted last week, may easily be bent round till the ends meet. The plate sent by Messrs. Elwell-Parker is in excellent condition. As to the use of mercury in the Julien plates, we expressed the same opinion as our correspondent on page 165 of our last issue.—ED. *E.*]

ELMORE'S ELECTRO-BURNISHING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I thank very much your correspondent, "C. J. S.," for his information as to conductivity of Elmore's copper, but I take this occasion to protest against the expression of the *specific resistance* in microhms, because it is not homogeneous. The specific resistance is given by the formula

$$s = R\frac{s}{l},$$

s being the specific resistance of a conductor of length *l*, section *s*, and resistance R. The dimensions of s are therefore

$$s = L\,T^{-1} \times \frac{L^2}{L}, \text{ or } s = R\,L.$$

It is the product of resistance by length, and should be expressed in *microhms-centimetres*, and not in microhms.

The specific resistance is not the resistance of a cube of one centimetre side, but is only *numerically* equal to that resistance. Analogous errors are very often found in denominations of physical quantities, because these denominations are calculated from units which represent these quantities instead of being derived from their physical dimensions, the dimensions being quite independent of choice of units.—Yours, &c.

GASTON ROUX.

Préparateur à l'Ecole de Physique et de Chimie Industrielles de la Ville de Paris, 91, Rue de Dunkerque, Paris, Dec. 17.

FAHRIG'S INFLUENCE MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: During 1880-84 I investigated the phenomenon of electrical influence in vacuum lamps, and came to the conclusion that the electrical phenomenon observed by exciting a lamp, although of great quantity, no known means exist to continue or to obtain tension. In 1882 I constructed a compound armature of these lamps, but failed to obtain tension "*spannung.*" The single-lamp armature, as per this copy, gives *best result.* It would be highly interesting to me to have the opinion of others upon these very instructive experiments. —Yours, &c. ERNEST FAHRIG.

ELECTRIC EFFECTS ON BEN NEVIS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following extracts from a letter from Mr. Omond, superintendent of the Ben Nevis Observatory, may be generally interesting. It was in answer to a question of mine as to whether anything electrically noteworthy was observable at that elevation.—Yours, &c., OLIVER J. LODGE.

"We have, I am glad to say, very few thunderstorms on Ben Nevis, but when they do occur they are apt to be severe. Once or twice thunder-clouds have rested on the hill-top, and when these pass off again there is always a sharp crack like a pistol shot heard in the lightning conductor, and frequently sparks have been seen springing out from the stoves inside the building. The conductor is, I fancy, not connected with these sparks; but whether there is any discharge from the top of it at the same time I cannot say.

"The conductor consists of a copper wire rope, about 1in. diameter, ending in a rod of copper with four sharp points round it near the top. This rod is fixed to the chimney—that is, to the highest part of the building—and the other end of the wire rope connects with an earth-plate, bedded in clay near the observatory.

"The only electrical phenomenon of at all frequent occurrence is St. Elmo's Fire, the brush-discharge look of which is sometimes seen on the conductor, stovepipe, and other projecting bodies on the roof, including observers, while cyclones are passing in winter. A description and discussion (meteorologically) of this will appear in the next part of the Scottish Met. Soc. *Journal.* "R. T. OMOND.

"21st November, 1888."

COMPANIES' MEETINGS & REPORTS.

The Swan United Electric Light Company (Limited).

The sixth ordinary general meeting of this Company was held at the Cannon-street Hotel last Tuesday, under the presidency of Mr. J. S. Forbes.

The SECRETARY (Major S. Flood Page) read the notice calling the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, in moving their adoption, said in the course of his remarks: I think we had better first deal with the profit and loss account. You see there that the debtor and creditor account is presented in much the usual form. We begin with the stock of lamps and material taken over from the previous year. Then come the purchases connected with the manufacture of lamps during that year; the expenses of administration, wages, and expenses at the factory, depreciation, and the balance. On the other side of the account the substance is really in the item of sales, less commission and allowances. Then there are other items of transfer fees and interest, and the stock of lamps in hand and material at the end of the year. The most important item of the lot is the sales, less commission and allowances, £40,120. That shows a considerable advance in the volume of the business as compared with the previous year—about £13,000 in round figures. The item of transfer fees and interest account is somewhat less—about £330. The interest we derive chiefly from our investments and our cash. We have called up a certain amount of our capital, and we have in hand a good round sum, which is invested, £5,000 being in Prussian Consols, an investment which is obliga-

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tory. The item of stock stands at £9,676, or £1,450 in excess of the same item a year ago. Adding these two sums together—what more we have sold and what more we have made and put away—there is about £14,150 more volume of business than we had in the previous year. On the other side of the profit and loss account the stock brought over at the end of last year stood at £8,221, and the purchases were £17,239. That is a compound item which embodies the material necessary to manufacture the large number of lamps sold, and it also includes a considerable amount representing lamps which this particular Company were obliged to buy of the Company in England in which we are so largely interested—the Edison and Swan Company. The wages and expenses at the factories were £11,923, and the depreciation is £1,079. The balance to the good is £8,332. That is the result of the year's working. The balance is only £780 in excess of that of the preceding year, and looking at the large additional volume of business, the analytical mind would want a reason for that small increase in the balance, which I can give. There is one happy feature in connection with the balance of £8,332 in that it is unencumbered by a claim for previous losses. In the year before we had a balance of between £7,000 and £8,000 of profit, but on writing down outstandings, in the shape of accumulated losses of previous years, that balance was reduced to £1,720. The proprietors may ask how it is that, having done £13,000 more business, we have only £780 more profit. I must tell you that competition is going on rather severely on the Continent—probably not quite so severely now since we ourselves have become members of a considerable Continental Company—but still it had gone on, and we thought it prudent to meet that competition by, in fact, bending to the storm of it, and reducing somewhat materially the price of the lamps, so that we have sold a larger number of lamps at a less price per lamp. Another reason for the small increase of profit is that in valuing the stock taken forward to next year we have been a little more severe against ourselves than we were a year ago. Being more anxious as to the permanent foundation on which this business is to rest than the profit of a particular year, we thought it prudent, in the face of a possible reduction of prices, to carry forward the stock at a less price. That has made a material difference in the figures, for we might have carried forward those lamps at a price of £2,000 or £3,000 more than we have done. If we have erred in what we have done it is on the right side. Turning to the balance-sheet, things remain pretty much as before. The capital is about the same, so is the item of forfeited shares. Sundry creditors figure at £2,943, or nearly £2,000 less than in the previous year. The balance from the previous year is £1,720, having been reduced to that amount by the writings off which I have explained, and then we have also the £8,332 which has been brought from profit and loss account, so that we have now standing to our credit in the balance-sheet £10,052. On the opposite side the cost of patent rights, as per last balance-sheet, stands at £105,852, increased by £930 by the expenditure on patent rights on the formation of La Compagnie Générale des Lampes Incandescentes. I explained at the extraordinary general meeting in June what we were doing with respect to the agreement with our French competitors. We have become a portion of the Company I have just mentioned, which has its seat in Paris, and this agreement has got rid of the litigation about the Swan and Edison patents. We appear in the balance-sheet as holding 800 fully-paid shares in the French Company, which is equivalent to the patents we put into that company. The £15,838 represents those 800 shares of 500fr. each, which we got as our proportion of the capital of that company—1,000,000fr.—representing the patents which both companies put into the common pot. That item of patent rights is thus reduced to £90,944. The outlay on factories, plant, &c., has been reduced from last balance-sheet to £8,396 by the realisation of plant, &c., to the amount of £193. Then this item is further reduced to £5,396 by a special reserve of £3,000 against depreciation. That £3,000 special reserve was made owing to our having an unsettled account at the Lille factory, which is now wound up and closed, and we have brought this £3,000 of reserve into the account in order to write down our outlay on factories and plant. Against the £5,396 we have made the usual depreciation out of revenue, and thus the item of outlay on factories, plant, &c., is brought down to £4,317. The only factory we have in hand now is at Kalk, near Cologne, on which a considerable sum has been spent from first to last. We have, however, written down the item to this £4,000 odd, which represents the value of that factory to us or anyone else to whom we may make it over. We contemplate extending to Germany the same arrangements we have been happy enough to bring about in most of the countries on the Continent. In that case we should probably make a fusion there, on the condition that the Kalk factory was taken over at a fair valuation, which I hope will considerably exceed the £4,317 mentioned. Then we come to our *bonne bouche*—the shares in the Edison and Swan Company, which figure at £208,478. Then the shares in the French Company stand at £15,838, and the 740 shares subscribed—meaning the subscription of capital of both companies to start the business there—represent £14,651, and the two together amount to £30,489, the amount of interest which we have got in that company. I am not going to prophecy, but our French colleagues, whom we saw recently in Paris, are very sanguine that the day is not far distant when there will be a fair dividend forthcoming on the outlay. 2,000,000fr. is not a large amount of money for which to have possessed all these patents, and to have started the business. They are already doing a good business. The item of sundry debtors—that is, people who owe us money—is reduced by £3,400 compared with that of last year, and we have no reason to expect any loss on the item. The stock on hand stands at £9,676, which is brought from profit and loss account, and which I have explained. Then come our investments, and you will see that in Prussian Consols, in Three per Cent. and New Two and-Three-quarter per Cent. Consols, and in cash we have nearly £40,000, so that we have a not inconsiderable sum if we want it to further extend our business. The two first paragraphs of the report embody all that I have told you. All the legal formulæ have been carried through with regard to the agreement between the Compagnie Continentale Edison, and which has resulted in the formation of La Compagnie Générale des Lampes Incandescentes. That company is on its legs, and the factory which they are erecting was practically designed by our friends in London. Meanwhile we are supplying them with lamps, partly from this country and partly from Germany, until they are in a position to manufacture them, which I daresay they will be next February or March. We state that the litigation as to the Swan and Edison patents is still dragging on in Germany; but we hope to bring it to an end. That, however, turns on whether the negotiations are successful, and whether the Germans will be disposed to follow the lead that we have shown them in France, so as to put our forces together and stop the litigation. We have been most anxious for the last two or three years to get rid of the litigation, and to do what has turned out wise in this country, and which I think will be wise there. Two Directors retire by rotation—Mr. J. W. Swan and Mr. C. H. Stearn. With respect to Mr. Swan, I apprehend that there will be no question as to the wisdom of re-electing him. As to Mr. Stearn, the position of our business in Germany and the possibility of its being absorbed within a short time by some other company, have brought us to the conclusion that it is not necessary or desirable that Mr. Stearn should be re-elected a Director. It may be both desirable and necessary to retain him in some other capacity, but not as a Director, and as we do not know what may happen when this fusion takes place, I dare say the best policy would be to keep that vacancy open for the present. Messrs. Quilter, Welton and Co., the auditors, retire. Now there is only one other matter which I should like to draw your attention to—what are we to do with this £10,000? I should like to take a little of it as the interest on the shares which I hold in this Company; but humanity is weak in some things. It appears to us that it is not prudent at present to distribute it, for the same reason that in the Edison and Swan Company, where the balance was very much larger—£25,000—we thought it necessary to carry it over for the present. The litigation in Germany involves the possibility—I am not going to say how remote that possibility is—but still there is the possibility of our being landed in damages, and it would hardly be prudent to part with the funds out of which those damages would be fairly met if they arose. I do not, however, want to alarm anyone in regard to that matter. If the litigation is put an end to on the same basis as it was in connection with the French Company, we shall have our £10,000 undiminished. I cannot imagine, from what I know of German law, or the probabilities of German law, the damages amounting to anything like £10,000; but it is an indefinite quantity. And then there is another reason. This Company of ours is an English Company, and we are advised that it is forbidden by law to distribute a dividend where there is what is called a "wasting" quantity, such as the cost of the patent rights. We have got rid of that portion of the patent rights which affects a considerable part of Europe, and there is a certain residuum left. We have got Germany, India, and the Cape, and some outlying places, but it is quite impossible to apply to Germany, India, or the Cape, in a concrete form, any portion of the £90,000. Meanwhile, with that £90,000 standing in our balance-sheet, we are advised that we cannot distribute a dividend. That is how we are advised, and, being so advised, it would be exceedingly rash, not to say imprudent, to attempt to distribute it. What I think may possibly arise may be this—what would in any case be a prudent thing to do. These patent rights have a certain time to run, and what we are trying to do in this Company and in the Edison and Swan Company is to so conduct ourselves by utilising the period in the improvement of the lamps, the production of the very best article, the extension of our connections, the founding of a going concern, and the having a good trade mark, as to be comparatively independent of patents or protection when the time arrives. I think the law is rather shadowy upon us, but we had better err on the safe side, and I for one should be prepared to recommend you to do one of two things, or both—out of any large profit to put aside a portion of it, and also to consider whether it would not be wise to do what the Courts of Law will allow us to do—reduce our capital. Assuming for the moment that the policy of setting aside any of the £10,000 against the expiring of the patents was not desirable, then it would be desirable if we could to distribute a dividend; but the law says you must not distribute anything as dividend until you have written down these patent rights. But you can write down your capital. Now, writing down the capital is a purely theoretical proceeding. It does not matter to us two straws whether our shares represent £3. 10s., £3, or £2. 10s. if the holders of these shares are entitled to all the profit made. It is simply a question whether the dividend shall be 5 per cent. on one figure or a larger per cent. on a smaller figure. You still remain the owners of all the property. That seems a plain and easy solution, and is a legal plan of relieving us of the embarrassment of locking up our dividend when we want to pay it. We should have to call a meeting for the purpose of doing that; but I am only now throwing it out to-day for the sake of preparation, and as a reason why, if the Directors were ever so anxious to recommend you to distribute this £10,000, they could not do so. He concluded by moving the adoption of the report and accounts.

The DEPUTY-CHAIRMAN (Mr. F. R. Leyland), in seconding the motion, said he fully concurred in what the Chairman had said respecting the balance in hand of £10,052. There was the possibility of their having to meet the costs of the litigation in Germany, and they could not persuade themselves that the patents they had now represented anything like the value at which they stood in the balance-sheet of £90,000. If they did not represent £90,000, it was quite clear they had only two courses open to them—either to replace the loss of capital by accumulating their profits until the loss was balanced, or to apply to the Courts for reducing the capital.

The CHAIRMAN invited discussion, but no shareholder rising to address the meeting, he put the motion and declared it carried unanimously. Continuing, he proposed the re-election of Mr. Swan, observing that that

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gentleman's reputation was European. There could not be a doubt that Mr. Swan being largely interested as a shareholder in the Company, and having such enormous scientific attainments, would be a most desirable colleague on the Board.

Mr. PELL seconded the motion, which was carried unanimously.

Messrs. Quilter, Welton and Co. were re-appointed auditors, and the proceedings then terminated.

The Pilsen-Joel and General Electric Light Company (Limited).

An extraordinary general meeting of this Company was held on the 14th inst., at the Cannon-street Hotel, Sir Rawson W. Rawson in the chair, for the purpose of considering, and, if thought fit, passing the following resolutions:—

"1. *That the Company be wound up voluntarily, under the provisions of the Companies Acts, 1862 to 1886.*"

"2. *That George Shead, of No. 9, Laurence Pountney-hill, Cannon-street, in the City of London, chartered accountant, and William Henry Trentham, of No. 4, Stanhope-street, Euston-road, engineer, be and are hereby appointed joint liquidators for the purpose of such winding up.*"

The SECRETARY (Mr. W. H. Trentham) having read the notice calling the meeting,

The CHAIRMAN stated that in what the Directors proposed they were acting upon a recommendation passed at the recent ordinary meeting. They had called the shareholders together to take the necessary further steps, and it was now for them to carry out what appeared to be the wish of the large majority of the shareholders at the late meeting. He concluded by moving the first resolution, as above.

Mr. G. L. WHATELY seconded the motion.

Mr. FELLOWS thought it was wrong for the Directors and shareholders to forego all control over the property of the Company, and to hand it over to two persons to dispose of as they might think proper. He suggested that the further consideration of the matter should be adjourned for two or three months. He eventually proposed the adjournment of the meeting for two months for this purpose, and to see if some offer could not be obtained so as to submit a definite scheme when it was decided to go into voluntary liquidation. His object was that they should liquidate with a definite scheme before them, and not hand over the business into the hands of two irresponsible persons, however able they might be.

Mr. FYFE seconded the amendment. He objected to the passing of the resolution at the present stage, because he considered that he had not had a proper opportunity for endeavouring to procure a customer. He had brought a customer to the factory, but the Directors and the Secretary told him that he had no authority from the shareholders or the Board to carry out his views. He brought a customer who was perfectly able and willing to buy the property, but when he saw there was unwillingness on the part of the Directors to effect a sale through him (the speaker) he had declined to go further into the matter. He still thought that if the proposal were adjourned for a month or two he could get a better offer than that submitted by Mr. Gwynne at a former meeting.

Mr. WHATELY, in reply, said that if they had accepted Mr. Gwynne's offer, which was rendered nugatory by Mr. Fyfe's action, they would have had 4s. a share returned to them. If they went into voluntary liquidation now they would probably get something back. If they postponed it for two months they would get nothing. If they postponed the consideration of the matter for six months they would probably have to pay a call, because several influential shareholders had threatened that if voluntary liquidation was not entered into they would move for a compulsory winding up.

After some further discussion, the amendment was put to the meeting and lost on the show of hands, and the original resolution was afterwards put and carried.

The CHAIRMAN subsequently proposed the second resolution for the election of Messrs. Shead and Trentham as liquidators.

The motion having been seconded,

Mr. FELLOWS objected to the appointment of the two gentlemen proposed, and moved the election of an official liquidator. He was informed, however, that it was not competent at that meeting for such a resolution to be brought forward.

The motion was then carried.

Woodhouse and Rawson (Limited).

An extraordinary general meeting of the shareholders of this Company was held on the 14th inst., at the Cannon-street Hotel, under the presidency of Lieut.-Gen. Sir John Stokes.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting.

The CHAIRMAN said: This meeting is called, though not strictly necessary, in order that we may have confirmed by you the auditors that we have temporarily appointed, and also in order that we may let you know the arrangements that are in progress with reference to the extension of the business, and have your confirmation of the same. You will be glad to hear that since we had the pleasure of meeting you some six months ago, we have gone on improving the organisation of the Company, which is now in good working order. In our installation department we have during the past year done work for Messrs. Peak, Frean and Co., the London Stock Exchange, Lord Brassey, Messrs. Guinness and Son, Messrs. Crosse and Blackwell, Drapers' Hall, Exeter Asylum, Messrs. W. H. Smith and Son, the Institute of Medical Electricity, and many other important firms and companies, and we have at the present time in hand orders for lighting the Palace of Mysore, from Sir Frederick Carden, and Messrs. J. W. Benson and Co., for extensions at the Drapers' Hall, and installations of varying degrees of importance. We are also in negotiation at the present time for the subcontract for lighting one of the most important districts of London, which subcontract we expect will come to considerably over £100,000. In our subsidiary Company working in Bradford, besides having put up installations throughout the district there are a number of establishments being fitted up by them, there being over twenty places in Bradford, such as the six principal banks, &c. Besides this large increase in our business there has been a striking advance in electrical business generally, and, as far as we can judge, there is likely to be a still greater increase. To give an idea of this growth it may be mentioned that we have not yet in any way felt the large increase that there will be in electric lighting derived from such companies as the London Electric Supply Corporation (Limited), with its large works at Deptford, the Metropolitan Electric Supply Company, and many of the other central stations that are being now started. It must be recollected that Woodhouse and Rawson (Limited) and its subsidiary companies lay themselves out for working for companies of this description, and that we hope to obtain a large amount of work resulting from their increase. To give an instance of the extraordinary increase during the last six months, we may mention that the turnover in electrical supplies of the Woodhouse and Rawson Electric Supply Company of Great Britain (Limited), one of our subsidiary companies, which does a merchant's business in buying and selling electrical goods and goods connected therewith, has increased nearly threefold. Foreseeing this increase some little time ago, the Woodhouse and Rawson Electric Manufacturing Company consulted us with regard to the extension of their Company, as they quite saw that the company in its existing state would be unable to cope with their business, and it was arranged to enlarge the company. As an instance of this increase, I may mention that they recently received an order for over 100,000 switches, the largest order ever given out. They also are in negotiation at the present time for an order for 200,000 incandescent lamps, and even at the double rate of their present turn-out, these two orders would fill them up with work for many months to come in their respective departments. The Manufacturing Company also wished to obtain the advantage of an amalgamation with another well-known business in the North of England, which also had a very great increase of business and was about to enlarge. We were in negotiation also ourselves for the purchase of various properties which we considered of value to our business, and on finding that the Manufacturing Company intended themselves to increase, we suggested their acquiring the properties we were in negotiation for. At this date there had been negotiations for some time between the Company and Mr. Rawson for the purchase of the founders' shares, as it was quite evident that should the business go on as we expected it was advisable for the Company to exercise its option and purchase the founders' shares. Our legal adviser told us, however, that it would be almost impossible to do this without the formation of a new company, as the Company could not purchase its own shares. Under these circumstances we considered it advisable to make an amalgamation, and we found that several other companies would be willing to join us. It may take a little time to complete this arrangement, but we wish to have the support of your approval to our doing this on the basis that the shareholders receive a bonus upon the amount paid up on their shares, and that there would be certain assets left in our hands from which we hope considerably to increase this bonus. At the present time we are paying dividends at the rate of 12 per cent. per annum, and we hope that by this amalgamation we shall be enabled to considerably increase this dividend, as we shall not then be obliged to set aside the large amount we now have to pay to the founders' shares. As you can quite see, it will not do to give any details of this amalgamation until it is further forward. You may recollect that at the meeting about six months ago I stated that we had just completed an arrangement of great importance to us. I am glad to say that this arrangement is now finally completed and in every way carried through, but I am not yet at liberty to divulge the same, as the interests at stake are too important. There is a company coming out in a short time called Elmore's Patent Copper Depositing Company (Limited), to work a process which we ourselves, as well as the most eminent experts of the day in such matters, consider one of the most valuable inventions discovered for a long time. We have been engaged in this for the past few months, and feel confident of making a large profit from the same. With regard to the matter of auditors, the late Mr. William Spain had, before this Company was formed, acted for Messrs. Woodhouse and Rawson, and his firm, Messrs. Spain Brothers, were appointed as auditors to our Company. We regret to have to say that since our last meeting Mr. William Spain has died, and we have appointed as auditors to the Company Messrs. Chandler, Pixley and Co. and Mr. Champness, who until shortly after Mr. Spain's death was a partner in the firm of Messrs. Spain Brothers, and who attended to Mr. William Spain's work. Messrs. Chandler, Pixley and Co. are well-known auditors, and are already auditors to one of our subsidiary companies. It is necessary to have this appointment confirmed. The first motion that I have to put to the meeting is that Messrs. Chandler, Pixley and Co. and Mr. Champness be appointed auditors.

Mr. HAYES seconded the motion, which was agreed to.

The CHAIRMAN: I have stated in my address that we seek for the moral support of the meeting to do that which we have the power to do. Seeing it is a matter of so much importance we prefer to have the confirmation and approval of the body of the shareholders as to our amalgamating the Woodhouse and Rawson (Limited) to a large company, which will give us a wider field of action, and hold out every prospect of success.

Mr. RAWSON, in reply to Mr. Hayes, said that the interests of the shareholders would be carefully looked after by the Directors, who were amongst the largest shareholders, holding between them a very large proportion of the share capital. They had done everything they could to make the new company such a company as would both command the work that was necessary for such a company, and that would also bring in, as the Chairman had stated, a larger dividend probably than was paid even now that being done by obliterating the founders' shares. In reply to Mr.

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Reed, he thought it would be necessary for the company to go into voluntary liquidation. The only objection to that course was that statements got into the newspapers that such and such a company was being wound up; but he thought that in their case everyone would know that it was only being wound up because of the business being taken over by the new company.

A SHAREHOLDER said he thought they were entitled to some more information respecting the new company. No other information had been given than that the company was proposed to be amalgamated with a larger company, and, for his own part, he would like to know more.

Mr. RAWSON, at the request of the Chairman, replied, stating that the difficulty with respect to giving details was that at the present time, though some of the agreements were practically completed, those interested in other businesses that were coming into the amalgamation were holding out for terms which were considered by others unfair, and if they knew what terms Woodhouse and Rawson (Limited) were getting they would be in a stronger position to ask for a larger sum than those connected with the amalgamation were prepared to give them. It was always undesirable prematurely to disclose details with respect to such a business. He did not suppose that the Chairman would have any objection to state privately to any shareholder what the arrangements were, and he (Mr. Rawson) believed that when the shareholders heard the arrangements they would consider them very beneficial for the Company.

The SHAREHOLDER said it seemed to him that they were going to take a jump in the dark, and they did not know whether their shares were to be sold to the new company at par or a discount. Only one meeting had been held, where an interim dividend was paid at the rate of 20 per cent., which took many months to pay, and at the time of that meeting it was said that there was enough in hand to pay 40 per cent. They were called upon now to sanction a matter of importance, but they did not know what the terms were.

The CHAIRMAN said he had stated in his opening address that the shareholders of the present Company would receive a bonus on their present shares, and a considerable bonus, too, so that there was no question as to their shares going at a discount.

A SHAREHOLDER asked how it was, in the face of the statement just made by the Chairman, that one could not readily sell the shares on the Stock Exchange at par.

The CHAIRMAN replied that he knew nothing about operations on the Stock Exchange.

Mr. RAWSON pointed out that the shares were so few in number. There were only 18,000 of the partly paid shares, and the total amount of the share capital on which the Company had to pay a dividend was only something like £70,000. They could not get a quotation yet, and people who wanted to buy or sell their shares had to wait until an opportunity was afforded by some other person requiring to buy or sell shares, as the case might be. At the same time, about three weeks ago one of the principal brokers on the Stock Exchange went to him (the speaker) and asked him as a favour to let him have some of the speaker's partly-paid shares on loan for a short time, the broker having sold some shares to a client abroad who had not sent in the certificates of transfer, and as he was unable to buy the shares in the market, they were going to buy them in against him. He (Mr. Rawson) lent the shares. Almost immediately afterwards he heard that there some were shares to be sold on the Stock Exchange, and a friend of his wrote and told him that he had given instructions to his broker to purchase, but the broker said that they were only offered for a very short time, and that they had been taken off the market. One benefit they would get by extending their Company, as was now proposed, was that they would get a quotation, and the buying and selling of the shares would then be greatly facilitated.

A SHAREHOLDER presumed that the Directors were not asking the meeting to do more than approve in principle the proposal, seeing that they had practically no information respecting it.

The CHAIRMAN: Naturally, when no details are submitted to you we are only asking you to approve of the matter in principle. The details will be submitted to you at a future time. In regard to the bonus, that will be taken by the shareholders in cash or shares in the new company at their option. He added that before the accounts could be submitted they had to be passed by the auditors, and it was necessary to obtain the shareholders' approval to the nomination of auditors, so that the accounts might be presented, which would be done before the close of the year. Having to call a meeting for the appointment of auditors, they had thought it right to mention the scheme generally that was on foot in the shareholders' interests. He then put it to the meeting whether in principle they desired to support the Board in amalgamating with other companies to form a larger company to carry on the business in hand, and the same was carried unanimously.

Mr. RAWSON said that an important shareholder had urged a point of considerable interest to those who held partly paid shares. By the agreements to which reference had been made, the present proposal was that the shareholders of Woodhouse and Rawson were to have a bonus of so much per cent. in the new company on the amount that was paid up on their shares at the date of handing over the business of the Company; and, in addition, the directors were to keep certain assets and realise those assets, distributing the proceeds among the shareholders in proportion to the amounts paid upon their shares. The pith of that arrangement was this, that to the shareholders of Woodhouse and Rawson at the present time it did not matter how much was paid up on the partly paid shares so far as regarded the bonus they were to receive from the new company, because all the shareholders in Woodhouse and Rawson (Limited) would participate alike—they would get the same percentage; but with respect to the assets left in the hands of the Company for distribution among the shareholders, the amount that each shareholder would receive on his shares would be determined by the amount paid up upon the shares; and the shareholder to whom he (the speaker) had referred, who held partly paid-up shares, maintained that it was unfair that the shareholders who had borne the brunt and burden of

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TELEPHONE EXCHANGES.

IN consequence of the increased use now being made of the System by the Subscribers, the Directors of the UNITED TELEPHONE COMPANY have decided to keep OPEN the Exchanges on CHRISTMAS-DAY and BOXING-DAY as on ordinary days.

By Order of the Board,

OXFORD COURT, E.C., *December 20th, 1888.* THOS. BLAIKIE, *Secretary.*

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the day a year or 18 months ago, when it was not known whether the Company was going to be a success or not, should not participate in the same way as the holders of the vendors' shares. It would make a great difference to Mr. Woodhouse's executors and himself, but as regarded himself he had agreed with the Board that if any of the holders of partly paid shares agreed to pay up all their shares before the arrangement was concluded they could do so, and in that case they would participate fully in the amount of assets to be divided.

Mr. REED asked whether the dividend earned by the Company would be passed over to the new company?

Mr. RAWSON replied that the dividend which had been earned up to the 30th June would be paid to the shareholders when the auditors had gone through the accounts and the matter had been agreed to at the general meeting.

The CHAIRMAN observed that an interim dividend had been paid to the 31st Dec. last.

Mr. RAWSON said that the dividend due up to the 31st inst. would probably be sunk in the bonus, but they could not tell yet. The profit they would make by the copper depositing company was claimed by the new company, and they would have to give that up. Those who paid up now in full their partly paid-up shares would not get a dividend for the past six months, but only from the time the amounts were paid up, and the dividend that was going to be paid would be up to the 30th June.

A SHAREHOLDER inquired whether the shareholders whose holdings were not fully paid up were to pay them up in full before they participated in the bonus?

Mr. RAWSON: No. It is at their option to pay up in full. They will receive *pro rata* according to what is paid up.

The proceedings then terminated.

Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company will be held at the Cannon-street Hotel, E.C., this day (Friday), at 2 o'clock, when the resolutions which were passed at the extraordinary general meeting of the Company held on the 3rd December last will be submitted for confirmation as special resolutions.

An extraordinary general meeting of the Company will be held immediately after the extraordinary general meeting announced above, when the following resolutions will be proposed as special resolutions:—

1. *"That the liquidators of the Company be and they are hereby authorised to consent to the registration of a new company to be named the Maxim-Weston Electric Company (Limited), with a Memorandum and Articles of Association which have already been prepared with the privity and approval of the Directors of this Company.*

2. *"That the draft agreement submitted to this meeting, and expressed to be made between this Company and its liquidators of the one part, and the Maxim-Weston Electric Company (Limited), of the other part, be, and the same is hereby approved, and that the said liquidators be and they are hereby authorised, pursuant to Section 161 of the Companies Act, 1862, to enter into an agreement with such new company (when incorporated) in the terms of the said draft, and to carry the same into effect with such, if any, modifications as they think expedient."*

NEW COMPANIES REGISTERED.

THE BRITISH ELECTRIC TRAMWAYS AND GENERAL SYNDICATE (LIMITED).—Registered by J. C. St. A. Angove, 27, Chancery-lane, London, W.C. Capital £10,000, divided into 2,000 shares of £5 each. Object, to promote, make, and provide, purchase, acquire, and dispose of railways, tramways, and other ways in the United Kingdom, and to equip, maintain and work any of such ways belonging to the company. The first directors shall be J. W. Haynes, and two others to be elected by the shareholders, and shall each hold 10 shares. The remuneration of the directors is not stated.

DOUSE'S PATENT FIRE CHECK COMPANY (LIMITED).—This company was registered on the 7th inst., with a Capital of £100,000, divided into 85,000 Preferred shares, and 15,000 Deferred shares of £1 each, to acquire the letters patent granted to Thomas Ralph Douse, for the manufacture of fire checks, and apparatus, and machinery therefore; to carry on business as a manufacturer and vendor of fire checks, and all material and apparatus necessary for making the same. The first subscribers are:—

	Shares.
T. R. Douse, Chatham, manufacturer	1
George Pepper, Chatham, chartered accountant	1
B. K. Wilson, 32, Bedford-place, Russell-square, W.C., law student	1
R. H. B. Wilson, Fritton, Norfolk, solicitor	1
H. J. Welch, 30, Stamford-street, S.E., clerk	1
J. V. Turner, M.E., 10, Credon-road, Rotherhithe, S.E.	1
H. Baines, 97, Harbut-road, Clapham Junction, S.W., electrician	1

There is not to be less than three, nor more than eight directors, and the first are to be appointed by the subscribers; qualification, 100 shares in the capital of the company; the remuneration to the directors is to be the sum of £500 per annum, or such larger sum as shall be equal to £100 for every 1 per cent. dividend over 15 per cent. per annum, but such remuneration is not to exceed £1,000 per annum. Registered office, 11, Gresham-street.

CITY NOTES, &c.

ANGLO-PORTUGUESE TELEPHONE COMPANY.—Coupon No. 2 of the Six per Cent. Debentures of this company, due January 1st next, will be paid, less income-tax, on and after that date by the Alliance Bank, 2, Bartholomew-lane, E.C.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 14th, 1888, amounted to £5,627.

EASTERN TELEGRAPH COMPANY (LIMITED).—This company announces the payment on 14th January next of interest at the rate of 3s. per share on the Preference shares of the company, less income-tax, for the quarter ending 31st December, 1888, and on the same day an interim dividend will be paid of 2s. 6d. per share in respect of profits for the quarter ended 30th September, 1888, on the Ordinary shares of the company, free of income-tax. The register of transfers will be closed from the 7th to the 14th January, 1889, both days inclusive.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH COMPANY.—This company declare an interim dividend for the quarter ended 30th September last of 2s. 6d. per share, being the same as a year ago.

SOUTH OF ENGLAND TELEPHONE COMPANY.—An extraordinary general meeting of this company was held at Winchester House, 50, Old Broad-street, London, E.C., on Thursday, the 13th inst., for the purpose of considering and, if approved, of confirming, as special resolutions under the Companies Act, 1862, the resolutions which were passed at an extraordinary general meeting of the company, held on the 22nd November, 1888. The meeting was presided over by Mr. D. Owen Bateson. The resolutions, which will be found set out in our issue of November 23rd, were proposed by Mr. Bateson and seconded by Mr. M'Gregor, and were carried unanimously.

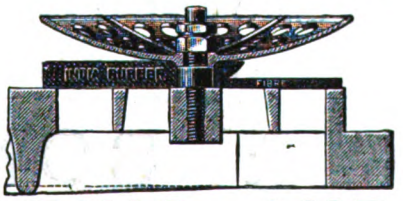
TELEPHONE COMPANY OF AUSTRIA.—Coupon No. 6 of the Five per Cent. Debentures of this company, due January 1st next, will be paid, less income-tax, on and after that date by Messrs. Martin and Co., 68, Lombard-street, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 14th, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited), were £4,695.

CHANGE OF ADDRESS.—The offices and show rooms of the United Electrical Engineering Company will be removed on and after the first of the year to 3, Princes-mansions, Victoria-street, Westminster.

NEW VALVE

No Rubber, Percha, or Leather.



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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Dec. 19, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Dec. 19, 1888.	
£			**TELEGRAPHS.**		£. s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	47 48	2 17 3	Jan., Apr., July, Oct.	47⅝	...
2,614,820	Stock	15/0	Do. Preferred	78 79	3 9 7	,, ,,	79¼	79⅛
2,614,820	Stock	nil.	Do. Deferred	15½ 16½	...	February	16⅛	15⅝
130,000	£10	5/0	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13½	13⅜
16,000	10	9·0	Cuba Submarine	14 14½	5 17 3	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4⅛	3 11 1	March & September	...	...
6,000	5	5/0	Do. Preference 10%	9 10	5 0 0	April and October	...	...
60,710	20	2/0	Direct United States	9⅛ 9⅜	4 2 1	Jan., Apr., July, Oct.	9⅜	...
380,000	10	2/6	Eastern	12½ 12⅝	4 16 0	,, ,,	12⅝	12½
70,000	10	3/0	Do. 6 per Cent. Preference	14½ 15	4 0 0	,, ,,	15	14⅝
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	109	108½
250,000	10	2/6	Eastern Extension	12⅝ 12⅞	5 1 0	Jan., Apr., July, Oct	12⅞	12⅞
22,050	10	8/3	German Union Telegraph and Trust	9 9⅛	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6¾ 7	5 7 2	Jan., Apr., July, Oct.	6⅛	6⅜
178,992	10	3/0	Do. 6 per Cent. Preference	14⅛ 14⅜	4 3 6	,, ,,	14⅜	14⅛
150,000	10	5/0	Great Northern	14½ 15	5 0 0	Jan., July, and April	15	14⅞
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
38,348	10	3/0	London Platino Brazilian	7½ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7	5 10 6	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	136	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98	97⅜
30,000	10	6/0	West Coast of America	9 9½	5 5 3	January and July	9 1/16	9¼
150,000	100	8%	Do. Debentures 8%	121 125	6 8 0	June and December	...	...
88,321	10	1% '78	West India and Panama	1⅝ 1⅞	...	...	1⅞	...
34,563	10	12/0*	Do. 1st Preference 6%	11½ 12	5 0 0	April and October	11½	...
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	13⅜ 13⅝	5 10 2	March & September	13 5/16	13
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	1/16 1⅛	5 10 0	Yearly	...	...
220,000	£1	2½%'87	Oriental (11s. paid)	⅜ ⅝	2 14 11	...	⅜	...
80,000	5	5/0	United	13⅜ 14½	5 5 3	June and December	14 1/16	13⅛
55,000	5	4/6	United River Plate	5⅜ 5⅝	...	January and July	5 5/16	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	4 4⅛	...	...	...	...
23,692	5	nil.	Do. (fully paid)	5 5⅛	...	February & August	5	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2 5/16	2 7/16
312,000	½	5% '86	Maxim-Weston	1/16 1/16	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	40 41	5 17 2	March and July	40⅞	40⅛
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17 17⅛	5 14 3	February & August	17⅛	17⅛

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 554.—Vol. XXII. FRIDAY, DECEMBER 28, 1888. Price 4d.

NOTES.

If central station electric lighting is to undergo that rapid development for which almost every other circumstance is now propitious, it is practically certain that in very many cases the local authorities will have to give their consent, tentatively and temporarily at least, to the erection of a certain amount of overhead wiring. This fact is, of course, already widely recognised; but at the present juncture it is most desirable that it should be brought clearly before the public—or at least the official—mind. Fortunately there need be no hesitation or misgiving in so doing, since we can point to the splendid record of a London company which has for a period of nearly four years maintained a network of overhead electric light wires—extending now to more than 100 miles—without giving rise to a single mishap. Electric light cables are not pretty things, it must be confessed, but (provided always that they are properly erected) that they will become a source of appreciable insecurity to the public we must and do emphatically deny. That the danger arising from overhead wires in general is simply infinitesimal is a fact which was recognised by the Committee of the House of Commons who had the subject under consideration in 1885. And we may be at least certain that electric light lines will be both more carefully erected and more thoroughly looked after than either telephone or telegraph wires.

On the other hand we fully recognise that, as a rule, the function of overhead wires in electric lighting should be merely tentative, and that as soon as ever the supply company has ascertained that the degree of custom on any particular route will justify the expense, underground mains should, as far as possible, be substituted. But for the pioneer work of supplying a customer here and there and for opening up new districts the comparatively cheap and equally effective overhead line is, from a commercial point of view, absolutely indispensable to any really extensive and important scheme; and we cannot too much insist upon the fact that the commercial side of the question is the most essential of any, and no reasonable success can be expected where it is ignored or overridden by the authorities. Of course wherever resort is had to the early methods of low-tension distribution in limited areas these remarks do not apply with quite as much force; but even here practical experience, as at Kensington Court, for instance, has fully shown the advantages of this method of procedure. The wisdom of the general policy which we have indicated is fully recognised by the company whose operations in London are on the most extensive scale, and we believe that the London Electric Supply Corporation are willing to guarantee to remove every one of their overhead lines within either two or three years of its erection.

We have often indicated our views on the general question of overhead wires, insisting more especially that they should be placed under legislative sanction and control; but we have been induced to recur to the subject this week in part by the fact that in Birmingham, where a sub-committee of the Corporation is about to adjudicate on several electric lighting proposals, the local press, or a part of it, is evincing a very strenuous opposition to overhead wires. The *Birmingham Daily Post* of December 20th contained an article which can only be regarded as an *ex parte* statement on the subject, and in the interests of municipal progress, no less than in the electric lighting interest, we trust that the Corporation will not come to a hasty decision, which will infallibly retard the advancement of a beneficial movement whose full value has yet perhaps to be appreciated. Possibly the committee may be able to take some hints for dealing with the question from what has been said above.

The answers elicited from the President of the Board of Trade in Parliament last week by Mr. Watt and Mr. Rowntree were not so explicit as might be desired, leaving still unsolved some doubts as to the powers of the Board in respect to the action of Electric Lighting Companies competing in one and the same area. As, however, the President admits it to be the duty of the Board of Trade to consider objections—not only those to which their attention is called, but those "which may occur to them"—it is satisfactory to the several companies whose works are in progress in the parish of Kensington that no objection has yet occurred to the Board to warrant their interference; nor did the hostile questioning of Mr. Rowntree appear to suggest any to the President's mind. He probably thinks, and rightly, that the best judges of their own interests in a matter of that kind are the undertakers themselves.

In a recent number of *La Lumière Electrique*, M. Paul Hoho examines the theoretical conditions of the system of so-called "battery transformers" (such as that proposed by Mr. Crompton in *The Electrician*, April 13th, 1888, p. 636, and carried out by him at the Vienna Opera House), in which the whole of

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the cells are charged in series, while the battery is divided into sets, each of which feeds a certain portion of the lamps, so that the charging current is divided between the cells and the external circuit. In the Vienna installation, for instance, we learn from Mr. CROMPTON (*loc. cit.*) that during about five hours two-thirds of the current goes direct from the dynamo to the lamps, but that when the demand is at a maximum this proportion is reversed. Now, for such a system M. HOHO points out that the dynamo current which traverses the parallel circuit (the battery and the lamp) is at any moment the same for each double section—since the sections are in series this is sufficiently obvious. It is equally clear that the number of ampere-hours absorbed in a given time in any double section is the same for all. But the portion of the charging current passing through any section of the *battery* at any moment is inversely proportional to the number of lamps burning at the time; whilst, on the other hand, the amount of current taken *from* the cells varies directly with the number of lamps.

FROM both these causes it follows that unless the number of lamps alight is always the same in each section, the batteries will acquire differing charges, and eventually some of the cells will tend to be run out whilst others are nearly fully charged. This state of things is hastened by the fact already indicated, that while the discharge is going on the battery which is being most rapidly discharged is the very one which is receiving the slowest charge. It is impossible to deny these obvious conclusions, but their practical importance may, no doubt, easily be overestimated. By interchanging the sections of the batteries and lamps, and by so arranging the rate of charge that time is allowed for charging some sections longer than others, much may be done to minimise the difficulty. For this, however, reliance must be placed upon the watchfulness and skill of the attendant in charge, and nothing but practical experience can prove the real value of the system. Mr. CROMPTON'S practical experience in Vienna has now extended over nearly another twelvemonth since he last communicated the results. And since somewhat conflicting rumours have lately arisen as to the later experience, it would be perhaps as well if he were before long to avail himself of an opportunity to report further.

ON February 16th of the present year, during the discussion at the Society of Telegraph-Engineers of Mr. KAPP'S Paper "On Alternate-Current Transformers," Prof. AYRTON, after describing the method of using an electrometer for the measurement of the power expended in an alternating-current circuit (see *The Electrician*, February 24th, 1888, p. 421), mentioned that this idea occurred to him first whilst listening to a Paper by M. JOUBERT during the Paris Exhibition of 1881. On coming away he said to Prof. FITZGERALD that he had just thought of a means of measuring alternating watts. "So have I," said FITZGERALD; and on comparing notes it appeared that their ideas were identically the same. But M. LEDEBOER, in *La Lumière Electrique*, now points out that, on the principle that the date of a discovery is the date of publication, the credit must in this case be assigned to M. POTIER, who published it in the *Journal de Physique* of October, 1881. We also find that this reference is given by MASCART and JOUBERT in their standard work on "Electricity and Magnetism."

IT will be remembered that the method in question involves two separate readings, and hence it is useless for continuous indication. This defect has been removed by MM. BLONDLOT and CURIE, who have constructed an electrometer in which the two opposite halves of the aluminium needle are insulated from one another. There are two pairs of semi-circular "quadrants," one above and one below the needle, and in order to damp the oscillations they are made of steel and magnetised. When used as a wattmeter the upper and lower plates on the same side are respectively connected together, and each pair is also connected to either end of the conductor (which may or may not possess inductive resistance), in which the expenditure of power is to be measured. The two halves of the needle are connected to the two ends of a non-inductive resistance, which has to be placed in series with the other conductor. The deflection is then directly proportional to the energy expended in the latter per unit of time. Calibration for alternating currents may easily be effected by means of a direct current.

IN connection with continuous currents the wattmeter is a very unimportant instrument, but we take it that with alternating currents the case is different. Such an instrument may or may not be useful in everyday working, but in many experimental and constructive investigations a trustworthy alternate-current wattmeter would be of the greatest service. The instrument just described is evidently an improvement upon the earlier arrangement, but it is still open to some objections. It may or may not be of consequence, in a given case, that a certain amount of power must be fruitlessly expended in the non-inductive resistance; although the smaller this waste is made, the smaller is the deflection to be read. Moreover, in the discussion already alluded to, Prof. AYRTON said that he had had the unhappiness to discover that quadrant electrometers were subject to a certain, or rather uncertain, coefficient of aberration, which rendered the theoretical formula inapplicable. On this point he promised further information—a promise which has yet to be fulfilled. It is to be hoped that the new instrument of MM. BLONDLOT and CURIE may prove to be free from this difficulty.

SOME of our readers will probably remember the interesting experiment of M. FOEPPL (*The Electrician*, June 1st, 1888, p. 105), in which he submitted Prof. EDLUND'S theory of the conductivity of a vacuum to what would appear to be a crucial test. He built a galvanometer with coils of glass tubing, and connected this with an induction coil in which the secondary coil also consisted of glass tubing, so that he had a complete circuit of rarefied air. No inductive effect of any kind was observed, even when the calculated E.M.F. was upwards of 5,000 volts, a result which seemed to show that in an ordinary vacuum tube the current passes entirely by convection. But a later experiment, also due to M. FOEPPL, casts some doubt upon

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this conclusion. He finds that when an exhausted tube (without electrodes) is placed within a solenoid through which *a Leyden jar is discharged*, luminous phenomena are seen to take place in the tube. It would be important to know whether this effect occurs both with oscillatory and non-oscillatory discharges.

Since Dr. Oliver Lodge made his remarkable discovery of the influence of the static discharge upon the dissipation of vapour, it has often been suggested that experiments should be made upon a large scale to see whether by this means a fog could be locally alleviated—or may we say—dislodged. The atmospheric conditions now existing in London are of the most favourable character, and our own experience would suggest that the neighbourhood of Fleet-street offers the best attainable conditions for an *experimentum crucis*. The *Liverpool Mercury* thinks that the experiment would be worth trying on the River Mersey "at any expense," and that, if successful, "the saving of life and property would be enormous." It also suggests that "the best way to try it would be to have a large balloon sent up some foggy day, and having it connected with a dynamo." If we may presume to offer an opinion of our own, we think a better way would be to get a good sized Wimshurst machine, mount it under shelter on the roof of a factory, or other building (where it could be geared on to some convenient shafting), and provide suitable discharging points. The whole thing could probably be done for £10. Why does not the Smoke Abatement Society take it up?

Some fresh experiments are reported from New York in connection with the electrical execution business. As the proceedings took place in the presence of Mr. Gerry, who is described as "the author of the law enacting that the death penalty shall in future be inflicted by electricity," we were at first led to believe that some welcome misgivings had crept over the New York authorities, and that they were opening their minds to sense and decency. But a quite other complexion is put on the incident when we learn that the tests were applied at Mr. Edison's laboratory, and by Mr. Harold P. Brown. Needless to say the current was an alternating one, and was laid on thick enough to kill first a calf and then a horse. The question to be decided, ostensibly, was one of weight, and as the calf was a light weight, and the horse a heavy weight, the current killing both with equal ease, the demonstration was deemed both comprehensive and decisive. For the real objects of the experimenters probably it was. But on the point at issue—that is to say, the efficiency of capital punishment by electricity—we should like to ask whether the calf and the horse were told what was going to be done to them? We can assure the New York authorities in this relation that there is all the difference in the world between your knowing what to expect and being taken by surprise. We do not doubt the possibility of killing the most hardened criminal by an electrical shock; but criminals, whatever their weight may be, are neither calves nor horses; and not even Mr. Gerry has yet suggested that malefactors should be done to death unawares.

Frankfort.—The Frankfort Offenbach Electric Railway will shortly be lighted along its entire length by arc lamps.

The International Telegraph Convention.—The Argentine Republic has joined the International Telegraph Convention.

The Patents, Designs and Trade Marks Act.—On Monday last the Royal Assent was given to the Patents, Designs and Trade Marks Bill.

Paris.—The Bourse de Commerce at Paris will shortly be lighted by 2,500 incandescent lamps. The dynamos supplying the current will be driven by compressed air.

Berlin.—The Berlin Municipal Council has decided not to accept the offer of the "Thuringer Bergbau Gesellschaft" to light the Muhlenstrasse by means of Brush lamps.

Ilfracombe.—The Ilfracombe Local Board has received three tenders for lighting the town by gas, electricity, and oil, and has "laid them on the table." The tender for the electric light mounts up to £1,500.

Threshing Corn by Electricity.—At the Giant's Causeway Mr. Traill is using an electric motor for threshing purposes, and recently a large stack of oats was passed through a threshing machine of the ordinary construction in about two hours.

The Electric Resistance of Cobalt in the Magnetic Field.—S. Joé *(Il Nuovo Cuinento)* finds that the electric resistance of cobalt in the magnetic field is *increased* in the direction of the lines of force, and *diminished* in the plane at right angles.

A New Electro-Technical Society.—A new electro-technical society, called the "Centro Technico dos Electricistas Brazileiros," has just been founded at Rio de Janeiro. The temporary address of this society is Arsenal de Marine, Rio de Janeiro.

Electricity in the Navy.—Mr. Lane, who has had charge of the electrical shops at Portsmouth without any distinctive position for a great number of years, has been appointed by the Admiralty to the new office of "electrician of the dockyard," with a substantial increase in pay.

Woolwich Arsenal.—We understand that Messrs. Drake and Gorham's tender for the lighting of the new central offices at Woolwich has been accepted, and although the building is to be ready for occupation early in January, the contractors foresee no difficulty in starting up the installation by the time required.

The Alkaline Accumulator.—Mr. P. Bedford Elwell writes us from Deauville to the effect that the statements which have been made with regard to the new alkaline secondary battery used by the French Government, and with which his name is connected, are incorrect in some respects, and were not made on his authority.

Royal Institution.—Prof. Dewar will deliver a series of afternoon lectures at the Royal Institution during this week and next, entitled "Clouds and Cloudland." These lectures, which are intended for a juvenile auditory, will take place on Saturday, December 29th, Tuesday, January 1st, Thursday, January 3rd, and Saturday, January 5th, at 3 o'clock.

Bradford.—At the Bradford Town Council Alderman F. Priestman, in moving the adoption of the proceedings of the Gas Supply Committee, explained that owing to a fire at the works of the contractor for the engines (Messrs. Willans and Robinson) the electric light would not be installed before the end of March. A number of persons had already signed agreements to take a supply of electricity for three years.

The Electric Light in the Field.—Some interesting experiments were recently made on Hampstead Heath by the members of the Medical Staff Corps, for the purpose of testing the capacity of small electric hand-lamps in searching for wounded men left after a battle. The results achieved indicate sufficiently well that the electric light thus used would be of great value, and tend to reduce the suffering of men left upon the field at the close of a fight.

St. Ouen.—The Société pour la Transmission de la Force has just commenced work on a central lighting station at St. Ouen, near Paris. The buildings will be large enough to receive engine power amounting to 500 horse-power. The current will at first only be supplied to St. Denis and Asnières, but later on

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the mains will be extended to Levallois. Asnières will have several subsidiary stations, where the current will be transformed and distributed to the consumers.

Telegraphic Communication with the Continent.—It is understood, says the *Daily News*, that a contract was signed between the Treasury and the Submarine Telegraph Company last week, prolonging the agreement at present existing, by which all messages from France, Belgium, and Germany pass through the hands of the Submarine Telegraph Company, until March 31st, 1889. The agreement would otherwise have expired on December 31st.

The Cardew Patents.—We understand that Messrs. Drake and Gorham have purchased the whole of the electrical patents held by Captain Cardew, R.E., the only exception being his measuring instrument in America. These patents include not only the well-known Cardew voltmeter but other devices in connection with central station lighting. They are proposing not to manufacture the apparatus themselves, but to license a few firms of good standing to make under royalty.

Central Station Lighting in Austria.—Our Vienna correspondent informs us that a new electric light company is to be started by the Union Bank, in conjunction with Messrs. Ganz and Co., of Budapest. This enterprising firm is doing so much work in all their various branches of manufacture that they evidently have almost more to do than they can get through. The new company intends to make central station lighting its speciality. The proposed capital is 2,000,000 florins (£200,000).

Taff Vale Railway and the Electric Light.—The directors of the Taff Vale Railway have decided to carry out the suggestion of their engineer (Mr. H. O. Fisher) to light two Penarth trains by electricity. The experiment will be tried for six months to commence with, and it is expected that the light will be ready early in the new year. The work has been entrusted to Messrs. J. B. Saunders and Co., electrical engineers, of Cardiff, who are the local agents for the Railway Electrical Contractors (Limited), of London.

Electric Launches.—The "Viscountess Bury" was launched last week from Platt's Eyot, Hampton. This boat measures 65ft. in length, with a beam of 10ft., and a mean draught of 22in., and has a displacement of 12 tons. The "Viscountess Bury" is constructed to carry about eighty passengers, and is propelled by twin screws, driven from two Immisch motors of 7½ horse-power, each of which takes current from 200 accumulators. The recharging is to be effected at any one of Messrs. Immisch's charging stations, which are in course of construction at several points on the River Thames.

Electricity in Honolulu.—The two telephone companies in Honolulu have 1,000 subscribers among a population of 2,000 souls. The Mutual Telephone Company have erected telephone posts upon the reefs in the bay to allow vessels to communicate with the shore. The subscription is only from 24 to 36 dollars per annum, and yet the companies make a good profit. The electric lighting is undertaken by the Thomson-Houston Company. The station is three miles outside the town, and is run by water-power; 60 arcs and 400 incandescents are supplied. The lighting is under Government control.

St. James's Vestry.—At a meeting of this Vestry on Thursday last week the Lighting Committee recommended that the application on behalf of the House-to-House Electric Light Supply Company for consent to apply to the Board of Trade for a license to supply electricity within the parish be opposed, on the ground that there were already enough companies in the field, and that the Board of Trade be requested not to grant a provisional order to the Westminster Electric Light Supply Corporation on the same grounds. On the motion of Mr. William Jenkins, the foregoing recommendations were agreed to.

Chelsea Vestry.—At a meeting of this Vestry last week the Hon. Conrad Dillon presented a petition from over 420 householders in the north-eastern portion of the parish on the subject of overhead wires. He said the petition was signed by persons in all the streets of the north-eastern portion of the parish. The overhead wires were a great nuisance, and should be put underground. The Vestry had taken great pains to tie down the Chelsea Electricity Company under stringent regulations to lay their lines underground, and he thought other companies should be also brought under control. He begged to move that the petition be referred to the Electric Light Committee.—After some discussion the motion was agreed to.

Belgian Commission for Applications of Electricity in the Interior of Coal Mines.—We learn that a Royal Commission of mining inspectors has lately been instituted in Belgium for studying the conditions of security to be provided in the applications of electricity underground in the workings of collieries (particularly in fiery mines) for firing, for fixed and portable lighting, and for transmitting motive power. The President of this Commission is Mr. Roberti, principal inspector, Brussels; and the members are the following inspectors:—Mr. A. Macquet, of Mons; Mr. J. Libert, of Liége, and Mr. E. Masson, of Charleroi, secretary, all of whom are electrical engineers. The first meeting took place on Monday last.

Edison Patents in Canada.—An action is being brought by the Royal Electric Company of Boston, in the Ottawa Courts, for the invalidation of the Edison patents for incandescent electric lighting in Canada, held at present by the Edison Electric Light Company of Montreal. Associated with the petitioners are the Westinghouse Company and the United States Electric Lighting Company, of Pittsburg, Pa. The cancellation of the patents is sought on the ground that Edison failed to comply with the Canadian patent regulations, which provide for the manufacture of the article in Canada two years after the patent is awarded. A large number of expert witnesses will give testimony. The Bell telephone patents in Canada were cancelled a few years ago for the same reason.

The City and Guilds Technical College, Finsbury.—The "special" courses announced to begin at the City and Guilds Technical College, Finsbury, in the new year include a set of lectures by Prof. Perry on "The Application of the Differential Calculus to the Practical Problems of Electrical and Mechanical Engineering," and a course of laboratory instruction in electro-deposition by Mr. Rousseau. The "ordinary" courses of electrical instruction at the Finsbury College are continued as usual. Prof. Thompson lectures on Wednesday on "Magnetism, Electro-Magnetism, Primary Batteries, and Galvanometers," and on Mondays on "Electric Lamps (arc and incandescent), Dynamos, and Motors." The electrical laboratories are so full that none can be admitted except those who either are engaged in the electric industries, or else have attended a preparatory course at one of the local polytechnics or science schools.

The Electric Light at Cannock Chase Collieries.—At the bi-monthly meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers, held at the Mason College, Birmingham, Mr. Arthur Sopwith, M.I.C.E., read a paper on "Electric Lighting at Cannock Chase Collieries." He described the system and exhibited lamps and copper cables used in lighting the collieries. He compared the cost of electric lighting with gas in favour of the former. The cables were protected by being enclosed in rough boxes, which were packed with coal-dust and tar. The shops, village church, schools and houses were lit, and there were eighty lights in No. 3 pit. A long and interesting discussion followed, and the president spoke of the Paper as a most excellent one, free from too much science, and laying before the meeting a positive and valuable accomplished fact. A hearty vote of thanks was given to Mr. Sopwith, and it was agreed to have the Paper printed for further discussion.

Bath.—At a meeting of the Urban Sanitary Authority on Tuesday, the 18th, Alderman Gibbs moved the adoption of a report from the Surveying Committee recommending that the seal of the Authority be affixed to a contract with Mr. Massingham for the electric lighting of a part of the district therein named. The contract, he said, was binding on any company to whom Mr. Massingham might entrust its performance. He could not say that he thought that the result attained would give universal satisfaction. He would have been very glad if they could have dispensed with those posts, which would be unsightly, and those overhead wires, which would also be unsightly, if not dangerous. He only hoped that the progress of

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science might enable them to get the wires underground.—Mr. Heywood wished the committee had seen their way to spend £240 and put the wires underground.—Alderman Brickmann objected to the overhead wires and to the whole of the city having to pay for the light when only one area would profit by it.—The report was then adopted, Alderman Brickmann alone dissenting.

Electric Tramways for Ballarat East.—At a meeting of the Town Council of Ballarat East, Australia, the offer submitted by Booth, Ellson and Co., of Queen-street, Melbourne, on behalf of the Australasian Electric Tramways Company, for the privilege of constructing tramways in Ballarat East, was considered. The following are some of the clauses of the tender, with the Council's recommendation thereon:—Company offer £500 per year for 30 years for sole right to use roads, &c., in Ballarat East, for tramways for 30 years, and quarter of the profits exceeding, or 10 per cent. divided.—Adopted. £250 to be paid before breaking road, £250 within 12 months, and £250 to be paid every six months. Systems—Overhead conductor, underground conductor or storage cells. Adopted.—Cars to be similar pattern to those on Melbourne lines; to seat 16 persons inside and six persons to stand on platform at end of cars. Adopted.—Whole of permanent way reverts to Council at end of 30 years. Provisions for Council to purchase prior to that term on payment of amount of paid-up capital, with interest for remaining term at 10 per cent.; or to purchase at end of 30 years at a valuation. Adopted.—The town clerk was empowered to apply to the Governor in Council for necessary power to delegate construction.

Submarine Telegraph Extensions.—Interruptions of telegraphic communication with Australia, owing to volcanic eruptions and other causes, have induced the Eastern Extension Telegraph Company to lay a third cable from Banjoewangie to a point in Western Australia, probably somewhere near Beagle Bay. The length of the new cable will be over 1,000 miles. The Telegraph Construction Company are working night and day loading this cable into their ship, the "Seine," which is to leave the Thames on Wednesday next to lay the cable. Mr. C. Riddle is the engineer in charge, and Mr. Thomas Clark is the electrician in chief. The Eastern Extension Company believe that when this cable is laid the chances of any breakdown in telegraphic communication with Australia will be very remote.—Another great cable of 700 miles is now being made by the Silvertown Company, for connecting Loando with Mossamedes, on the West Coast of Africa; while the Telegraph Construction Company are making a cable of 1,500 miles to connect Mossamedes with Cape Town. This work will be completed in March next, and thus there will be two telegrapic routes to South Africa, one *vid* the East and the other *vid* the West Coast—an important boon in the event of any grave crisis again arising in that quarter of the world.

Resistance of Alloys.—C. L. Weber, in Wiedemann's *Annalen*, XXXIV., 1888, gives the results of some experiments on the resistances of alloys of tin and lead, and tin and bismuth, at high temperatures. Pure tin on melting exhibits a sudden increase of resistance, and a similar phenomenon occurs with an alloy corresponding to the formula Pb_2Sn_7. In the case of other alloys the increase of resistance may be classed under two heads; first, in the case of all alloys there is a rise at (the first melting point) about 180°C., and a further rapid increase of resistance until the fusion is complete; the former rise is the more marked the simpler the formula of the alloy. The alteration in resistance in all cases is somewhere about 50 per cent. For tin-bismuth alloys the case is different; these have all an approximately constant melting point, about 140°C., but differ in their other properties. In the case of alloys containing only up to 12 per cent. of bismuth the melting point is not very noticeable, though apparently a little lower than pure tin; from 25 to 50 per cent. bismuth alloys the resistance suddenly decreases, and then begins again to increase at 60 to 80 per cent. Bismuth shows a steady decrease of resistance during the whole period of melting; the smallest change noticed was in the case of a 54·5 per cent. bismuth alloy, but Herr Weber considers it probable that an alloy between 55 and 60 of bismuth corresponding to the formula Bi_3Sn_4 would have a still smaller alteration in resistance. Temperature coefficients lie between 0·2 to 0·4 per cent., and 0·05 to 0·08 per cent., for the alloys in the solid and liquid state respectively. Herr Weber concludes from his experiments that the decrease in resistance of bismuth, when melted, is due to an essential property of the metal, and not to an accident of structure.

St. George's Vestry.—On Thursday, the 20th inst., the Electric Lighting Committee recommended that an application from the London Electric Supply Corporation to light with electricity the area between Hamilton-place and St. George's Hospital, as far down Grosvenor-place as Halkin-street, be granted upon an agreement being entered into embodying the following conditions, viz.:—That the corporation bear the whole expense of the laying of wires, &c., for making the experiment, and that a light quite as good as that now given by gas be supplied to the satisfaction of the Vestry, who will pay £300 per annum for the lighting of the area, the agreement to be for a period of twelve months certain, after which it should continue unless determined by three months' notice on either side. That the corporation reinstate the parish lamps and paving, if removed or interfered with, to their present condition, and that no use of the parish lamps by the corporation shall in any way interfere with their being lighted by gas, at any time, if so required, and the details as to the exact system of lighting be left to the corporation. The Electric Lighting Committee recommended "That the Vestry resolve that it is in their opinion to the advantage of this parish, and, so far as the Vestry could see, of the inhabitants of London generally, that joint-stock companies should commence operations for electric lighting under licenses rather than provisional orders."—Lord Hobhouse, in moving the adoption of this report, said the company had already wires laid within this area. The expense of lighting the area by gas was about £300, and so they had fixed that sum in the agreement.—Mr. Southon seconded the motion, which was agreed to, with a rider prepared by Sir Walter Phillimore, regretting that the Board of Trade had refused to enter into the proposal of granting licenses on a principle which would seem to prevent any licenses in future being granted to them.

Frictionless Bearings.—An ingenious improvement in the manufacture of frictionless bearings has been invented by Mr. Frank Garrett, M.I.C.E., of Leiston Works, Suffolk, and is being introduced by the firm of which he is the principal. These bearings are made of Babbitt's metal, or some other similar alloy, and they are cast in solid metal chills, which are worked up with the greatest accuracy, so as to produce externally of the bearing the exact outline of the interior of the plummer block, whilst the interior of the bearing corresponds mathematically with the journal which it is intended to support. The chills are, moreover, so designed that the bearings would form a complete circle but for the intervention of a dividing plate, which separates the metal and forms two castings, each complete in itself, and together forming a perfect circle. The cast-iron plummer blocks are also so constructed as to present uniform interiors for the reception of the bearings. The chief merit of this system (says *Iron*) consists in the absence of the friction caused in all gunmetal bearings, which have been bored or machined, however carefully, in consequence of the exposure of the rough edges of the minute particles which form the surface of the bearing, and which catch against microscopic projections on the surface of the journal. In Mr. Garrett's bearings no boring or machining takes place, the metal being cast in chills. The bearing surface is consequently composed of unbroken molecules of metal, and since these molecules do not possess individual strength to resist the friction of the journal, they are flattened to a perfect polish, and a great economy of power and lubricant results. It has long been usual to bush metal bearings by pouring Babbitt's metal in a molten condition into the cavity existing between a journal and its bearing, the latter being purposely bored out larger than the journal for this purpose; but it has remained for Mr. Garrett to produce accurately-finished and interchangeable bearings of this material, such as can be readily replaced by others of mathematical identity when replacement becomes necessary. This system was exhibited on Messrs. Garrett's stand at the Smithfield Club Show.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 161.)

An elaborate investigation into the duration of induced currents was made by Blaserna.*

A commutator was constructed which consisted of two insulating cylinders keyed on one shaft and having on part of their surface brass coverings cut into steps (*see* Fig. 15). These cylinders were capable of being set in any relative position to each other on the shaft. The shaft could be revolved at a high rate of speed, and its velocity ascertained by a siren plate attached to the axis. This siren plate consisted of a disc pierced with holes against which was directed a jet of air. From the pitch of the musical note given out, when ascertained by comparison with standard tuning forks, the speed could be determined. Two springs pressed against the hubs of these cylinders and two against the surfaces of these cylinders, and a current entering by the hub was conducted to the brass coating and escaped by the other spring, if the cylinder was in such a position that this last spring was pressing on the metal part. The apparatus, therefore, formed a device by which each pair of springs might be brought into electrical contact for a definite portion of the time of a revolution of the cylinders and be insulated also for a given time, each pair of springs being in connection relatively to the other in a determined manner for a determined time. In the circuit of the one cylinder and pair of springs *m* M was placed a battery, primary coil, and tangent galvanometer, and in the circuit of the other pair a secondary coil and sensitive galvanometer. This being prepared, the primary coil P and the secondary S were placed a given distance apart. On revolving the commutator it periodically interrupts the primary current, the time during which the primary current is kept on depending upon the position of the spring M on its cylinder. The other cylinder can be so set as to collect either the direct or inverse secondary currents, and send them in series through the sensitive galvanometer, the time during which this secondary circuit is closed being capable of regulation by the adjustment of the spring M_1. In his experiments Blaserna first investi-

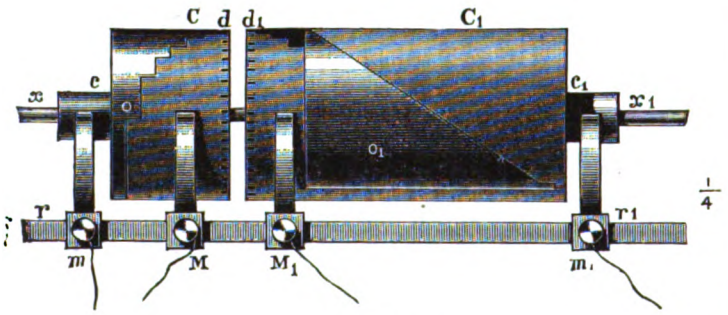

FIG. 15.

gated the duration of each of the induced currents. The interrupters were so arranged relatively to one another that whilst the primary circuit was made and broken, the secondary circuit was not closed until a small time after "making" the primary, and then broken again before the primary was broken. By adjusting the secondary interrupter a position could be found in which the galvanometer just showed no current. The interval between the closing of the primary and the opening of the secondary was then the interval occupied by the secondary current, and this was the duration of the "make"-induced current. Blaserna found that the "make" secondary (inverse) lasts a longer time than the "break" current (direct). For the coils used the times were—

Inverse secondary lasts ·000485 second.
Direct secondary lasts ·000275 second.

He next proceeded to obtain the curve of each current, and to determine the time of arrival at a maximum.

* Blaserna, *Sul sviluppo e la durata delle Correnti d'induzione*, Giornale di Science Naturali, Vol. VI. (Palermo, 1870).

The secondary interrupter was so set that the secondary circuit was closed just before the primary, and opened after at a certain definite interval of time. The galvanometer thus received a current which was made up of repeated doses of the whole quantity of the induced current up to a certain fraction. Knowing the speed of the commutator and the coefficient of the galvanometer, the value of the whole quantity of the induced current, extending over a certain fraction of its whole duration, was known; and from those observations, repeated at regular progressive intervals during the whole period of the current, the value of the ordinates of the current curve can be obtained. For if the curve (Fig. 16) A P P′ B (upper figure) represents the variation of current during a time A B, so that P X = y represents the current strength at a time X and P′ X′ represents the current strength after a very small interval of time X X′ = $d\,t$. Then the area P P′ X′ X = $y\,d\,t$ represents the quantity of electricity which has passed in the time X X′. Call this d Q. Hence $d\,Q = y\,d\,t$, or $y = \frac{d\,Q}{d\,t}$.

Suppose another curve A′ P′ R (lower curve) is drawn on an equal abscissa A′ B′, such that its ordinate at every point represents the whole area of the upper curve up to the corresponding point—that is to say, the lower curve is a curve such that its ordinate P′ X′ is proportional to the area A P X of the upper curve, A X (upper curve) being equal to A′ X′ (lower curve) when the time interval $d\,t$ becomes very small. It is easily seen that if the area A P X (upper curve) is called Q, and the ordinate P X is called y, that the tangent of the angle P′ Y X′ (lower curve), which the geometrical tangent drawn at P′ makes with the axis A′ B′, and which is represented by $\frac{d\,Q}{d\,t}$, is proportional to the ordinate P X. Hence the upper curve is a derived curve of

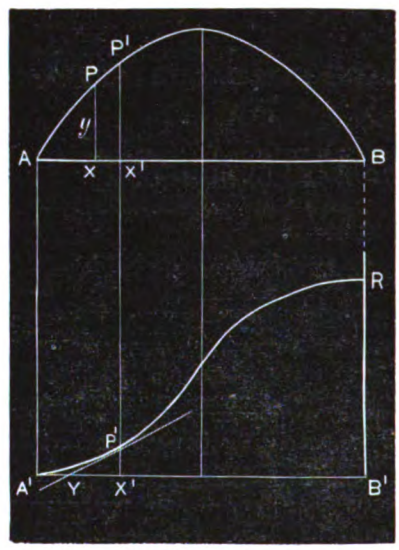

FIG. 16.

the lower, and if we are given a curve like the lower curve, the ordinates of which represent the whole quantity of electricity which has from a given epoch flowed past a point, we can, by drawing a curve whose ordinates represent the *slope* of the first curve, obtain a second curve, which is a curve of current. In this way it is possible to describe the current curve, and to determine its form and position of maximum.

Blaserna found that the greater the distance apart of the primary and secondary—in other words, the less the mutual inductance—the less was the maximum value of the secondary current, and the greater the delay in the appearance of that maximum. This is in accordance with theory. In the case of the "break," or direct secondary current, he found the delay in establishing the maximum not so great, and the maximum ordinate was greater, though the total duration of the current less. He established by direct experiment the equality of the quantity of the two induced currents. When the coils were very near together the induced current at starting established itself by a series of *electrical oscillations*.

(To be continued.)

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DYNAMO REGULATION BY MEANS OF A THIRD BRUSH.*

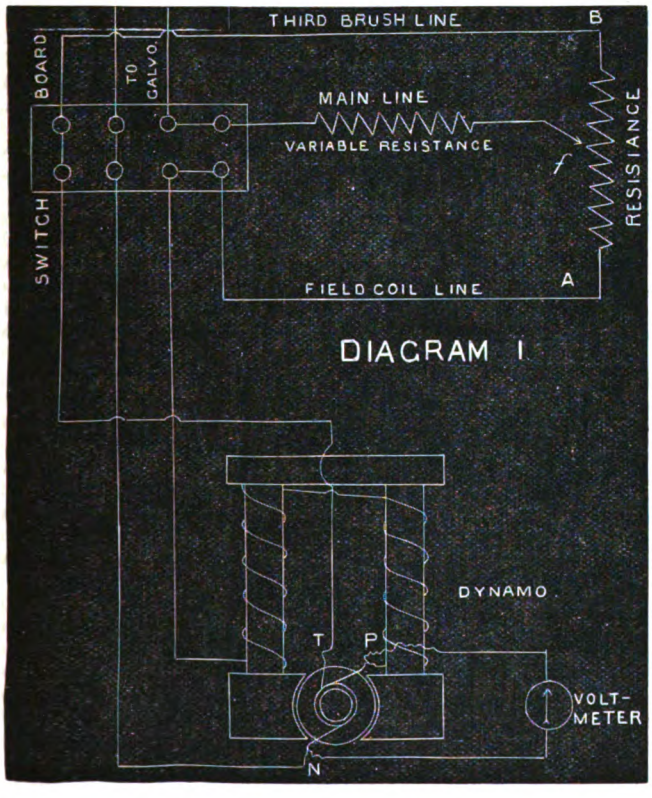
BY EDWARD CALDWELL, A.B., M.E.

The following study of methods of third brush regulations of series dynamos for *constant current*, was taken up at the suggestion of Prof. Nichols. During the progress of the experimental work it was discovered that a similar method of regulation might be applied to a series-wound dynamo for the production of a *constant electromotive force*. The investigation was made to include, therefore, the applicability of this method of regulation to a series-wound dynamo, both for a constant current and a constant electromotive force.

The dynamo used in this work was a small series-wound machine, with two upright field magnets of the Edison type and a Gramme armature. The cores and yoke were of the best Norway iron. The principal dimensions and constants of the machine were as follows :—

Diameter of armature, outside	$4\frac{3}{4}$ inches.
Length „ „ „	$2\frac{1}{4}$ „
No. „ „ coils	30
Resistance „ through brushes	·72 ohm.
Diameter of field-magnet cores	$2\frac{3}{8}$ inches.
Length of field-magnet cores	$7\frac{3}{8}$ „
Size of yoke	2in. by $2\frac{3}{8}$in. by $10\frac{1}{4}$in.
Turns of wire on each field coil	785
Resistance of each field coil	·8 ohm.

A third brush, held by an independent brush holder, was placed upon the commutator between the regular brushes. This could be set at any desired angle in advance of the positive brush, a pointer indicating the angle upon the graduated circumference of a wooden ring placed concentrically with the shaft. Another pointer indicated in a similar manner the angular lead of the regular brushes.



Each of these pointers was set at zero of the graduated scale when the brush which carried it rested at the upper end of the vertical diameter of the commutator—a point midway between the edges of the pole-pieces.

The field was explored for distribution of potential around the commutator by a modifiation of a method described by Prof. Brackett, in a Paper read before the American Institute of Electrical Engineers in 1884, and published in Vol. I. of the *Transactions*.

The current was measured by a tangent galvanometer, the coil being formed of a single ring of copper, 50 centimetres in diameter, and of rectangular cross-section. Its constant was determined by comparison with the large standard tangent galvanometer, in the magnetic observatory of Cornell University. The deflections could easily be read to tenths of a degree.

The E.M.F. was measured by an Ayrton and Perry voltmeter, which had previously been calibrated. The voltmeter was shunted across the regular brushes of the machine.

	Volts.	Amperes, main line.	Amperes, field line.	Amperes, third br. line.	Ohms in main line.	Extra res. in field.	Angular advance of third brush.
Table 2.	11·	1·70	·39	1·31	5	16·5	24°
	29·	„	·77	·93	10	12·9	
	39·	„	·99	·69	15	9·4	
	46·1	„	1·47	·23	20	5·1	
	50·	„	1·68	·02	25	1·4	
Table 3.	7·	1·70	·29	1·41	5	19·3	48°
	29·	„	·78	·92	10	15·1	
	41·2	„	1·12	·58	15	12·0	
	49·	„	1·52	·18	20	7·9	
	52·3	„	1·84	−·14	25	3·0	
	53·5	„	1·96	−·26	30	0·	
Table 4.	12·	1·70	·35	1·35	5	20·	72°
	35·	„	1·01	·69	10	16·8	
	47·7	„	1·48	·22	15	11·4	
	51·6	„	2·05	−·35	20	6·5	
	53·4	„	2·35	−·65	25	2·3	
Table 5.	43·	3·23 (?)	1·09	2·16	5	21·	96°
	47·	1·84 (?)	1·24	·60	10	21·	
	53·5	1·70	2·13	−·43	15	10·	
	55·1	„	2·61	−·91	20	5·	
	55·0	„	2·76	−1·06	25	2·5	
Table 6.	51·	1·70	1·88	−·18	5	21·	120°
	54·3	„	2·61	−·91	10	12·	
	55·1	„	2·68	−·98	15	9·9	
	55·3	„	3·08	−1·38	20	4·7	
	55·3	„	3·37	−1·67	25	1·7	
Table 7.	29·	1·70	·77	·93	10	12·9	24°
	29·	„	·78	·92		15·1	48°
	35·	„	1·01	·69		16·8	72°
	47·	——	——	·60		21·0	96°
	54·3	1·70	2·61	−·91		12·0	120°
Table 8.	39·	1·70	·99	·69	15	9·4	24°
	41·2	„	1·12	·58		12·0	48°
	47·7	„	1·48	·22		11·4	72°
	53·5	„	2·13	−·43		10·	96°
	55·1	„	2·68	−·98		9·9	120°
Table 9.	46·1	1·70	1·47	·23	20	5·1	24°
	49·0	„	1·52	·18		7·9	48°
	51·6	„	2·05	−·35		6·5	72°
	55·1	„	2·62	−·91		5·0	96°
	55·3	„	3·08	−1·38		4·7	120°
Table 10.	50·	1·70	1·68	·92	25	1·4	24°
	52·3	„	1·84	−·14		3·0	48°
	53·4	„	2·35	−·65		2·3	72°
	55·0	„	2·76	−1·06		2·5	96°
	55·3	„	3·37	−1·67		1·7	120°
Table 11.	1·	1·00	·10	·90	5	18·7	36°
	10·	„	·32	·68	10	16·6	
	28·	„	·40	·60	15	13·0	
	29·	„	·62	·38	20	11·8	
	38·	„	1·00	·0	30	4·0	
	40·5	·92	1·07	−·15	40	0·	
Table 12.	5·	1·50	·31	1·19	5	17·4	36°
	25·4	„	·49	1·01	10	14·9	
	34·0	„	·83	·67	15	11·5	
	41·2	„	1·22	·28	20	6·0	
	45·	1·38	1·56	−·18	30	0·	
Table 13.	14·0	2·00	·48	1·52	5	16·5	36°
	34·5	„	·81	1·17	10	13·0	
	44·	„	1·48	·52	15	6·8	
	47·5	„	2·00	·0	20	0·4	
	45·0	1·38	1·56	−·18	30	0·	
Table 14.	25·	2·50	·61	1·89	5	15·8	36°
	43·6	„	1·50	1·00	10	9·0	
	47·7	„	2·38	·12	15	1·7	
	48·0	2·14	2·22	−·08	20	0·	

* Revised abstract of graduating thesis, Sibley College, Cornell University, June, 1888. Reprinted from the New York *Electrical Engineer*.

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The resistances used in the external circuits were made of German silver wire coiled in the form of a spring, and stretched upon upright wooden frames. By means of a copper hook contact could be made at any desired point. These coils were standardised by comparison with the coils of an Elliot Brothers resistance box of the dial pattern.

The arrangement of the apparatus during the first portion of this investigation differed from that of the Waterhouse Electric Company in their system of third brush regulation for constant current* only in that the point of contact of the main line with the resistance coils of the regulator was varied by hand instead of by automatic means.

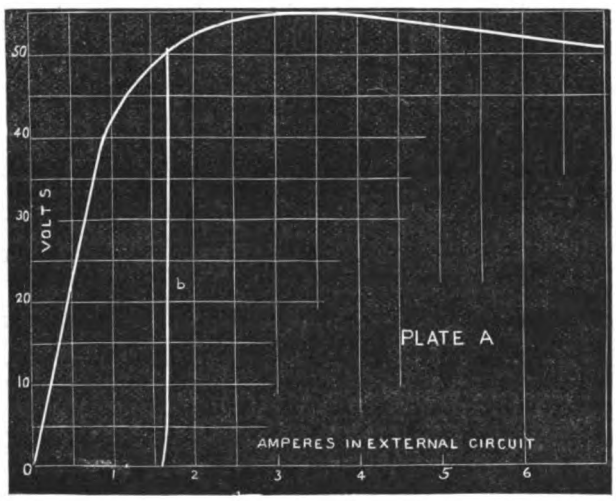
The connections used are shown in Diagram 1. The switchboard contained eight small mercury cups—two each for the terminals of the galvanometer, the third brush line, and the main line, and was so arranged that the galvanometer could be placed in any one of the three circuits.

The machine was first run at 2,500 revolutions as an ordinary series machine with two brushes, these being adjusted to the non-sparking position with a lead of about 12 degrees. Table 1 gives the data obtained from which the characteristic curve in Plate A is plotted.

TABLE 1.

Volts.	Amperes.	Volts.	Amperes.
11	·21	55·1	3·09
39	·87	54·6	4·11
49	1·54	51	6·90
54	2·35		

It will be noticed here that a very small amount of current is sufficient to saturate the field-magnets because of the very large number of turns of wire on the field-coils.



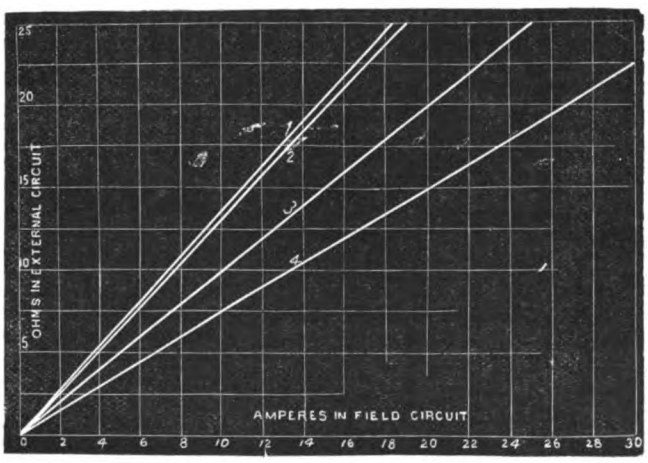


PLATE 1.

With the third brush upon the commutator a study was made of the effect of increasing the angular distance between the third and positive brushes. The tabulated results are given in Tables 2 to 6. The third brush remained fixed through each set of observations, and the main brushes, at a lead of 12°, through all the five sets. The resistance between the third and positive brushes was 21 ohms.

The curves of relation of E.M.F. and current, of which curve *b*, Plate A, is an example, need not be plotted, as an inspection of the tables will show that within the limits of regulation the curves are superposed vertical lines, if the volts be taken as ordinates and the amperes as abscissæ. Curves 1 to 4, Plate 1, are plotted from Tables 2 to 5.

These curves are straight lines, and they show that the condition necessary to constancy of current in a series dynamo, namely, direct proportionality of external resistance and current in the field coils, has been secured. They also show that the greater the lead given to the third brush, the greater the field current necessary to keep the external current constant, the external resistance being the same. This will also be seen by a comparison of columns 3 and 7 in Tables 7 to 10. These tables are compiled from Tables 2 to 6.

But the most interesting as well as the most important phenomenon, shown by all these tables alike, is the change of sign of the current in the third brush line. Under some conditions the third brush acts as a positive brush, and under others as a negative.

Tables 2 to 6 show (1) that with each position of the third brush, on increasing the external resistance, the current in the third brush circuit at first decreases, becomes zero, and again increases in the opposite direction; and (2) that the further the third brush is in advance of the positive the higher is the current in the third brush line at first, the sooner the zero point is reached, and the higher the current rises in the opposite direction.

Tables 7 to 10 show (1) that with advance of the third brush, the external current and resistance being kept constant, the E.M.F. continues to rise while the current in the third brush line gradually decreases, passes through zero, and again increases in a negative direction; (2) that this zero point is also the point of maximum additional resistance in the field, and of minimum additional resistance in the third brush line; and (3) that this zero point is reached sooner the higher the external resistance.

It was at first thought that these changes might be due to a distortion of the neutral line of the armature, since with each change in external resistance there was a corresponding change of strength of field, while the current flowing up through the armature from the negative brush remained constant. An exploration of the field, however, by the method alluded to, showed that under extreme variations of current in the field, the neutral line did not change position as much as 10 degrees, an amount quite insufficient to account for the changes shown in the tables.

It will be noticed that the application of the third brush destroys the symmetrical flow of current in the armature. If the third brush be positive it will take off a part of the current flowing up on that side of the armature, and the coils lying between the third and positive brushes will have less current than the other coils. But if the third brush be a negative, the current returning to the armature by the third brush line will be added to the coils lying between the third brush and the positive. Neither will the current flowing up on one side of the armature be equal to that on the opposite side, since the resistances of the two paths offered to the current are not equal. The result of this unequal distribution will be, in extreme cases, to throw the neutral points of the armature off the ends of a diameter and on that side of a diameter where the coils are traversed by the weaker current. If, however, as was the case with the machine used in this investigation, the magnetic moment of the field is very great as compared with that of the armature, this effect is inappreciable.

But these variations of current in the third brush line may be satisfactorily explained without reference to the distortion of the diameter of commutation. It is a well-known fact that the total E.M.F. generated in the armature coils increases around the commutator from the negative brush to the positive, each coil adding its share to that induced in the coils preceding, and that the E.M.F. again falls, through the same range, from the positive brush around the external circuit to the negative brush.

Let E_d be the drop of potential between the positive brush and the point at which the third brush line joins the main circuit, and let E_i be the rise of potential between the third and positive brushes—that is, the E.M.F. induced in the coils which lie between these brushes.

It is evident that if $E_d = E_i$, no current will flow in the third brush line, its two ends being at exactly the same potential. But if $E_d > E_i$, the third brush will be at a point of higher potential than the other end of the third brush line, and current will flow *out of* the armature through the third brush. If $E_d < E_i$, the reverse effect will be produced, and current will flow along the third brush line *into* the armature.

Now $E_d = C' R'$, where C' and R' are respectively the current and resistance of that part of the circuit between the positive brush and the junction of the third brush line with the main line. Also,

$$E_i = \frac{2}{\pi} w H' A' = 4 n H' A'.$$

* See *Electrician*, October 12, p. 738.

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A′ being the "equivalent area" of the coils lying between the third and positive brushes; H′, the strength of the field; w, the angular velocity; and n, the number of revolutions per second of the armature.

There will be equilibrium between the ends of the third brush line when $E_d = E_i$, that is, when

$$C' R' = 4 n H' A'.$$

The speed remaining constant, this equation shows that any one of three changes will make $E_d > E_i$, and so make the third brush positive.

(1) *Increase of* R′.

This will occur if the finger *f*, Diagram I., be moved towards the point B. This change will produce a corresponding decrease of C′ and H′, but below the saturation point these practically vary in direct proportion, and will not change the value of the equation.

(2) *Decrease of* A′.

This may be done by bringing the third and positive brushes nearer to each other, thus decreasing the number of coils between them.

(3) *Increase of* C′, the field-magnets being saturated.

If H′ remain practically constant because of the saturation of the iron, an increase of C′, caused by a decrease of the resistance of the external circuit, will make $E_d > E_i$.

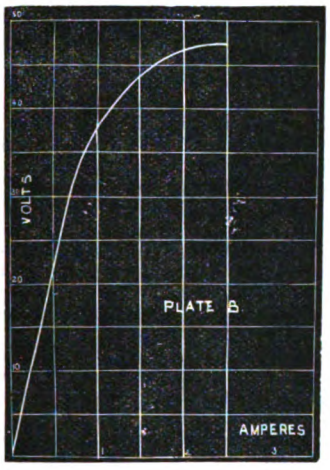
The three opposite changes will make $E_d < E_i$, viz. :—

(1) *Decrease of* R′.

(2) *Increase of* A′.

(3) *Decrease of* C′, the field-magnets being saturated so that H remains constant.

A change of speed, n, would produce a complex change of all the factors except A′. All of the variations of current in the third brush line may be traced to one or more of these causes.



It will be noticed that the difference of potential between the main brushes is always the same—between 50 and 51 volts—when the current in the third brush line changes sign. This is the point at which the new characteristic crosses the characteristic of the regular series machine, as shown in Plate A, where the characteristic curves from Tables 1 and 2 are plotted together. When the third brush is positive it robs the field coils of a part of their current and adds this to the main-line current, and when it is negative it diverts a portion of the current from the main line, adding it to the field-circuit line.

It will also be noticed that curves plotted between field current and E.M.F. from Tables 2 to 6 coincide with the characteristic from Table 1. This would necessarily be so, since in Table 1 the external current is also the field current.

No higher E.M.F. can be reached on the constant-current curve than that obtained from the machine worked as an ordinary series dynamo, the limit being reached as soon as the iron of the field-magnets becomes saturated.

The horizontal distance between corresponding points on the constant current curve and on the curve of E.M.F. with field current, measures the amount of current flowing in the third brush line at that point, and also shows whether it is positive or negative.

It is evident that the point of crossing of the two characteristics —that is, the point at which the current in the third brush line becomes zero, will depend upon the *amount* of the constant current in the external circuit. Tables 11 to 14 give the data obtained when the external current was held respectively at 1·0, 1·5, 2·0 and 2·5 amperes. The points obtained by plotting field-current with E.M.F. fall, as before, upon a common curve, as shown in Plate B, and constant current curves for 1·0, 1·5, 2·0 and 2·5 amperes cross this curve at 38, 44, 47 and 47·5 volts E.M.F. A curve for ·5 of an ampere would cross the characteristic at about 22 volts.

Below the saturation point of the iron the relation between current in the third brush line and E.M.F. is one of direct proportion. When the saturation point is reached current in the third brush circuit may increase indefinitely without increase of E.M.F.

No very large *negative* current is obtained in the third brush line until the third brush is 90deg. or more in advance of the positive. This would seem to indicate that the constant-current characteristic cannot be carried much, if any, above the regular-series characteristic unless the third brush has a very large lead, and this is objectionable because of very bad sparking at the third brush.

This arrangement is in reality equivalent to a compound-wound dynamo in which one set of field coils is made to carry the current for both the series and shunt coils of the usual type of compound-wound machine. Referring to Diagram I, and the last line of Table 4, it is clear that the field coils act as *series* coils in carrying a current of 1·70 ampere from P, the positive brush, around the external circuit to the negative brush N, and that at the same time they act as *shunt* coils in carrying ·65 of an ampere from P, around the field-magnets and back to T, the third brush. There is, however, this further distinction to be made between this arrangement and the usual type of compound dynamo—that that part of the field current which partakes of the character of a shunt becomes zero under certain conditions of the external circuit, and that beyond this point the shunt circuit acts as a differential coil wound upon the field-magnets. This is effected, not by an opposing current being sent around the field, but by the shunt becoming a *shunt around the series field coils*, thus depriving them of a part of the current they would otherwise receive, and so weakening the field. This is shown by the first line of Table 4, where, of the 1·70 ampere in the external circuit the field coils carry but ·35, while a current of 1·35 ampere is shunted around the field by the third brush line and added to the current in the main circuit. Though common enough in motors, the writer is not aware of any other case in which a differential coil or anything analogous to it is applied to a generator.

The arrangement then embodies at once the principles of three distinct types of dynamos, the type used being determined solely by the resistance of the circuit if the external current be kept constant. In keeping a constant external current, however, the resistance of the series field changes.

These three types are :—

1. Series dynamo + differential shunt coils (or rather what has the same effect as differential shunt coils).

This type is brought into use when the third brush is at a higher potential than the junction of the third brush line with the main line and a portion of the total current of the armature is diverted from the field coils, decreasing the strength of the field.

2. Plain series dynamo.

This is the type made use of when both ends of the third brush line are at the same potential and the current flowing in it is *nil*, which occurs at the point of intersection of the two characteristics.

3. Series dynamo + cumulative shunt coils.

This occurs when the junction of the third brush line with the main line is at a higher potential than the third brush and current flows into the armature at the third brush.

It should be noticed that in this combination the total resistance of what corresponds to the shunt-circuit of the field, including the resistance of the field coils and whatever resistance may be placed between the third brush line and the field line, is a constant, while the resistance of what corresponds to the series circuit of the field is variable, being changed by the movement of the finger *f*, Diagram I, along the resistance A B.

(To be continued.)

LEGAL INTELLIGENCE.

Edison and Swan Electric Light Company v. Holland and Others.

TUESDAY, DECEMBER 11.

The ATTORNEY-GENERAL commenced his reply this morning, and stated that he should not condescend to notice various points which had been dealt with by counsel on the other side. He did not go back from anything which he had said before with regard to the importance of this invention of Edison's being the real starting point of the improvement in electric lighting, and he entirely denied that Swan and Stearn were not indebted to Mr. Edison for what they had done. The learned counsel was about to refer to the specifications to prove his position, when

LORD JUSTICE COTTON said that they had stopped Mr. Finlay from going into this, considering that it was better that he should go into the evidence to prove that part of his case

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The ATTORNEY-GENERAL said that Mr. Finlay was not stopped in his description to the Court on the previous day.

LORD JUSTICE COTTON: I say if there is evidence to show that before a certain time there were difficulties with carbon burners which were afterwards removed by certain processes being adopted, that is legitimate to go into, and it may remove the effect of the great start then made in electric lighting; but we stopped Mr. Finlay from going into the specification and saying, Here is an invention. We do not know that it is an invention by merely putting before us the specification.

The ATTORNEY-GENERAL: I accept the distinction; but I must be allowed to say that if there remain in your lordships' minds any lingering doubts upon the suggestion that the step was taken by these subsequent improvements, not by Edison's enunciation, I claim to show that they are every one identically the same combination, and there is no evidence whatever of any difficulty being removed by the subsequent improvements. There is no evidence whatever beyond the fact that the lamps were cheaper, and that they lasted longer, and that they could be made more quickly, of the later lamps being anything different from Edison's combination; in fact, their strongest witness admits that I am right in that respect. Mr. Finlay has told your lordships that this burst of electric lighting came from something else; but that is a question of evidence. I say that it is as clear to-day as it was in 1880 or 1881 that it was the enunciation of Edison's combination that had made the step, and nothing else. They say that Edison taught Swan nothing. I desire to demonstrate from the evidence that Swan took fairly, and honestly, and readily, Edison's publication of 1879, and used it, and for that purpose I will refer your lordships to the evidence between Mr. Swan and Mr. Stearn in 1879. Mr. Swan had worked that paper carbon 15 or 20 years before, and had abandoned it as hopeless. F J B 1 had no copper and platinum caps, and the thing is put into more concrete shape by Mr. Stearn himself. Mr. Swan had evidently designed something to get the carbon to bend, and in the correspondence between Mr. Swan and Mr. Stearn on the subject of these inventions it was clearly shown that there was something about carbon bending, and that they little appreciated the fact that the carbon conductor could be bent before it was carbonised, and from February, 1879, to February or March of 1880, these two gentlemen never reverted to the vessel wholly of glass. Lord Justice Fry and Lord Justice Bowen had held that the difference in combination and the Edison design was the difference between failure and success. F J B 1 was abandoned as an experiment, believing that they had gone into a wrong path; as far as we can tell, incandescent lighting might still have been undiscovered but for Edison's publication in the month of November, 1879, for everybody knew everything before, and it was known to Swan, and I think with all that knowledge they were going backwards to F J B 1 instead of onwards. I am going to show that this platinum and the same method of carbon conductor continued through to September, 1879, and the departure made by Swan was after he had heard what Edison had done. This attempt to deal with the platinum caps was their method of trying to get rid of the large conductors, which went through the glass and thereby cracked the glass. But there is a more important point in the giving way between the carbon and the contact where the carbon joins the platinum. The learned counsel proceeded to read the correspondence between Messrs. Swan and Stearn, and then went on to say that as to the alleged absolute worthlessness of Edison's discovery he should show that the mode of connecting the thin piece of carbon at the platinum wires is to-day one of the best and most serviceable ways of doing it, and that it is a complete novelty and an absolute departure, and that which is plagiarised and improved in all directions. The difficulty of contact was very great until the appearance of Edison's patent. The hairpin carbon broke down because they did not understand how to attach it, and the correspondence between Mr. Swan and Mr. Stearn shows that they were trying to construct the pencil on blocks, and there was a picture [produced] which has thinned down to a very minute line in the middle, something like a partial thread, and they thought that the only source of danger was removed; but nevertheless they abandoned the experiments. These experiments between Messrs. Swan and Stearn demonstrate the fallacy of Mr. Finlay's position, that Edison taught the world nothing. When this is understood it will be shown that it was Edison's enunciation of that invention that did solve the question of success, and there never has been anything to improve it to this day in the connection of multiple arc lighting except simply an improvement in the manufacture of Edison's patent, making it cheaper, longer lived, and more commercial, and better for public purposes. So far from Mr. Swan asking for an improved conductor, he was trying to see whether or not he could get something to free his carbon from defects which would make the old conductor useless.

LORD JUSTICE BOWEN asked what had been disclosed in the publication of *Nature* in October, 1879.

The ATTORNEY-GENERAL: What Edison had disclosed in *Nature* was the patent for freeing platinum from occluded gases, viz., running upon the pumps. It was described on October 2nd in *Nature* as "The connection of heat in vacuo in metals." Mr. Edison there describes the experiment of electric lighting with platinum, and he then describes running on the pumps with practically the same alteration as in the specification. Swan and Edison were both engaged on the running on the pumps; but Swan was not attacking the improved conductor.

LORD JUSTICE LINDLEY: Stearn said that?

The ATTORNEY-GENERAL: Yes. I mention this because my learned friend's argument is that Mr. Swan in 1879 was working at filamentary conductors, and he now said that Heaviside and Proctor saw these filamentary conductors in 1879. That was a complete mistake on the part of those who instruct my learned friend. The thing they were both working at was running on the pumps. There was no suggestion by Mr. Swan to alter his conductor into a filamentary shape, or anything like it, until he got the description of the thread carbonisation of Edison. Swan never thought of "filament" until February or March, 1880. It is not correct to say that Swan ever put "filament" into his patent in January, 1880. Edison always publishes the substance of his inventions before the complete specification goes in, and in the provisional specification of Mr. Edison, which was in England in the month of June, three months before the time spoken of by the other side, Mr. Edison had actually mentioned carbon as being able to be freed from air by this process. Up to that time Mr. Edison had not developed the filamentary idea. Messrs. Swan and Stearn never attempted to make a thread conductor for six months after this, and it was a little strong for his opponents to say, "Why, Heaviside and Proctor saw these lamps in 1879." Mr. Edison had anticipated Mr. Swan entirely, and Mr. Edison in his provisional specification had described three months before, though it was a secret document until December, what it was alone that had been done by Mr. Swan. The running on the pumps had been secret and experimental, and Stearn said:—"I now show that this had been published, because if Edison has patented it we shall be debarred from running on the pumps." They were completely anticipated. My friend has tried to ridicule and scoff at everything that has been done by Mr. Edison. Up to June, 1879, Edison was working with the platinum filament. The carbon filament was practically only then incubating, it was not developed. On the 3rd November, within seven days of Edison's provisional specification, Mr. Stearn—who is a great expert in the use of Sprengel pumps and Crookes' tubes, from which the air has to be exhausted to a very low vacuum indeed—was referring as to the use of the Sprengel pump, and I used that to show how little Swan and Stearn appreciated the conditions under which they were labouring; so little did they appreciate what could be done that they proposed to let the lamps always stand in water so as to get the heat generated by the current conducted through the water. Is it possible that the greatest experimenter in electric lighting could have gone so far wrong? We shall show that Mr. Swan got his idea, and admits that he got it, from the information he obtained from Edison's patent. I shall show the impossibility of Proctor and Heaviside's evidence, that they saw thread lamps running and burning successfully in Swan's own laboratory and also at Stearn's house.

LORD JUSTICE LINDLEY: I thought you gave that up, Mr. Finlay.

Mr. FINLAY: The difficulty was this, that we could not say that with regard to this there was publication.

The ATTORNEY-GENERAL: But you said so over and over again.

Mr. FINLAY: That was the difficulty, and I thought your lordship was referring to that.

LORD JUSTICE COTTON: I understood you to say that these thread lamps had been used.

Mr. FINLAY: Then I misunderstood your lordship; but I do press it as showing that in the summer of 1879—that is to say before November, 1879—Swan and Stearn were making lamps with this slender carbon conductor. The Attorney-General has used the word "thread" lamp. If my friend by that means a lamp by which the carbon conductor is made of thread, that is based on Swan's evidence. If by that he means that the conductor was slender, like a thread, I say that the effect of the evidence of those witnesses, Heaviside and Proctor, and of Swan and Stearn's cross-examination, is to show that in the summer of 1879 Swan was making lamps with slender threads, which in that sense might be considered thread conductors.

The ATTORNEY-GENERAL: My friend has no right to interrupt because the witnesses say that they saw the lamp, and they described it as a thread lamp, with a loop like the filaments hanging up in the court in which your lordships now sit.

LORD JUSTICE COTTON: It was an attempt to shorten the case, and I got into a difficulty.

Mr. FINLAY: I said with regard to that: I rely upon this as showing that Mr. Swan was making these lamps at that time in substantially the same way with these slender conductors, and I never for a moment abandoned that.

The ATTORNEY-GENERAL: Mr. Finlay heard my opening, when I said I could demonstrate on Swan and Stearn's evidence that nothing of the kind was ever made until March, 1880.

Mr. FINLAY: We rely upon this, that Swan, as shown by Heaviside's evidence, was making lamps with slender conductors, and that is shown by Swan's cross-examination. I ask your lordships to look at the evidence of Heaviside and those other witnesses taken together with the whole evidence of Edison and Swan. The result of that evidence is that Swan really admits practically that he was making lamps with this Carré carbon hair-pin shape before November, 1879. He does not admit it in terms, but the effect of that is so. Then with regard to the filaments made with paper which Heaviside says he saw, I say on Swan's cross-examination in all probability Heaviside is right upon that point, because on the 20th January, 1880, Swan took out a patent for the paper filaments. On the 29th November, 1879, he wrote that letter to *Nature*, which was published on the 2nd January, 1880, which stated that within the last six months he had completely got over the difficulties of the making of carbon conductors from paper.

The ATTORNEY-GENERAL: From running on the pumps?

Mr. FINLAY: That is what he said in evidence. It is a letter in which he referred to the experiments with charred paper for filaments, and he said that within the last six months he had entirely overcome the difficulties which formerly stood in his way. In evidence he tried to explain that it referred only to the pumps, but what I submit is that putting that together with the fact that three weeks afterwards he took out the patent for the cardboard conductors, and the inference is irresistible that Heaviside is right that before November, 1879, he saw the slender carbon conductors made out of paper. With regard to the third point, the thread, I call attention to the ambiguity of the thread lamp. If by that the Attorney-General means a lamp with a slender carbon conductor, I say that he is proved to be wrong. If he means that a carbon conductor was made out of thread, then I say Swan is very

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clear that he never used thread to make a carbon conductor until February, 1880. The evidence is practically supported by the cross-examination.

The ATTORNEY-GENERAL: I have to go back to my own argument, and it is somewhat difficult to shorten it. It is quite wrong to suggest that although they saw the horseshoe fine conductor that they saw the thread before it was carbonised. Swan had no exhausting or Sprengel pump, and the exhausting was done by Stearn. I am justified in saying that, so far from F J B 1 being a combination to produce a lamp, it was adandoned by the people who knew anything about it, and it was only unearthed for the purpose of anticipation. Mr. Finlay says all that gentleman has done is to take a combination like F J B 1 and to make a slight modification; but my answer is that F J B 1 led people astray. Then Mr. Finlay said we shall prove that before November, 1879, F J B 1 developed into thread lamps, and they called Proctor and Heaviside to prove that prior to Edison there were thread lamps. So far from their being told nothing by Edison's enunciation of his patent it was the one thing which made every other lamp a success. I say that F J B 1 was absolutely nothing before Edison's invention, and, therefore, I say that Edison's invention was one of enormous merit.

LORD JUSTICE COTTON: Do both sides take these letters between Swan and Stearn as a compendious statement?

The ATTORNEY-GENERAL: I do not think that objection could be made to them now.

LORD JUSTICE COTTON: My brother Lindley says that the letters are admissible as to what was done by Stearn and Swan.

Mr. FINLAY: When they were asked to call Swan and Stearn Sir Horace Davey withdrew his objections to the letters being put in. What I demur to is their being accepted as a compendious statement.

The ATTORNEY-GENERAL: What that correspondence proves is that if they had been working at the carbonised papers with a view to a patent they would have been forestalled by Edison's publication. Mr. Swan had noticed the statement in *Nature* as to Edison adopting carbon, and he wrote that years ago he had used paper in the shape of a horseshoe, and that within the last six weeks he had conquered the difficulties, and produced a perfectly durable incandescent lamp. Now, was it conceivable that if Mr. Swan had shown Heaviside and Proctor hundreds of paper lamps, he would not have referred to that? In February, 1880, their lordships would find that platinum caps were still being used, but nothing was known of Mr. Edison's invention more than was disclosed in the *Daily News*. The Attorney-General hoped that the correspondence had demonstrated to their lordships that anything like a trial of thread had never entered Mr. Swan's mind up till now.

LORD JUSTICE BOWEN: There is this qualification—supposing a hairpin is a filament, the hairpin seems to have worked.

The ATTORNEY-GENERAL said that no one hairpin had worked. It was never published prior to the 10th of November, 1879, and not suggested, unless his opponents could prove Heaviside and Proctor. He contended that the hairpin was not a filament.

LORD JUSTICE BOWEN: You say it was not successfully used before November, 1879, and not then successfully used in fact.

The ATTORNEY-GENERAL said that Proctor and Heaviside were asked about horseshoe lamps, but their lordships would find that there was no suggestion of hairpins being seen by them; but the whole point with regard to their evidence was that they made a mistake of a year. Then he came to the account communicated to *Scribner* by one of Edison's men, and that article described the difficulty as being that of getting a conductor that would bear the intense heat of the current. Lampblack had been found to contain air, which interfered with success. Then Mr. Edison used a simple thread which he found to answer the purpose. He would call their lordships' attention to the House of Lords' judgment that, if a thing be taken and improved, improvements being the only alteration, that invention had been pirated.

LORD JUSTICE COTTON said that that was not disputed.

The ATTORNEY-GENERAL continued that he would demonstrate that every lamp since made, except Bernstein's, had Mr. Edison's new combination, and that every lamp made for multiple arc lighting had it. For days their lordships had been addressed from the point of view that it was not the 1879 specification that made a useful lamp, but what came afterwards that made it. Within a few weeks of commencing Mr. Swan succeeded with thread lamps, and brought out his parchmentised thread patent. The date of these lamps was proved by alterations to the Otto gas engine, which ran them.

LORD JUSTICE BOWEN: Which lamps?

The ATTORNEY-GENERAL: Any thread lamps.

LORD JUSTICE COTTON: The great advantage of these filaments is that there is not heat sufficient to melt the connections or heat the glass.

The ATTORNEY-GENERAL said that was so, and it was stated in the patent. As to lamps having large wires and suitable glass, no use of them had been proved, but only a theoretic opinion given. Sir Frederick Bramwell had been asked as to the advantage of a small filament, and had replied that it lay in enabling the size of the mains for domestic lighting to be reduced. Asked when he first made a thread lamp Mr. Swan said certainly not before 1880, and he thought towards the middle of the year. Mr. Finlay had endeavoured to show that there had been no change in electric lighting in consequence of Edison's combination, but Swan had abandoned the work of years for it, and in a few weeks found success. The question was, when was the step in advance made? The fact of houses being lighted in 1880 by Mr. Swan's lamps showed the extraordinary step in advance made by Edison's combination. It was to be noticed that when they began to use thread lamps they carbonised for themselves, and that further showed the enormous step—the courage of the step to take a thing like thread for a carbon. The merit of Edison's combination was that he swept everything previously known aside. The infringers came and said they knew it all before, and all that it was necessary to do was to diminish the size of the stick in F J B 1, but Edison told them to bend and then carbonise. The vibration of the filament noticeable in Edison's lamp could not be attained by anything made from Carré's carbon. He took the infringing lamp and found it had the vibrating qualities. Edison brought the word "filament" into the electrical art, and no conductor was a filament unless it had the properties of Edison's conductor before it was carbonised. What fresh fact could his learned friend show to prove that F J B 1 was a filament?

LORD JUSTICE LINDLEY: What is the thing in F J B 1?

The ATTORNEY-GENERAL said it was a pencil. It was essential to a filament that it could be taken, twisted and twirled, before carbonisation, and the best description of "filament" was to be found in the specification itself: "Any fibrous, vegetable substance that will leave a carbon residue after heating in a closed chamber." He said that filament meant what Edison described.

Mr. FINLAY: What is it?

The ATTORNEY-GENERAL: "Filament" was so entirely connected with Edison's invention that it had become a common word for conductor, and every single lamp of the millions now used in multiple-arc lighting were Edison's combination. Improvements cheapened the lamp and made it more successful, but no one suggested that the improvements caused the lamp to succeed where it had been a failure—he was referring to subsequent improvements. If it were right to describe F J B 1 as a filament, he did not know why his learned friends could not rely upon King, of 1845, as an anticipation. Bernstein's was said not to be an infringement because of the elastic joint put in to get over the difficulty, which Edison got over in another way. Bernstein had altered the mode of attachment on the one crucial point where every other lamp followed Edison. The definition of a filament was something that could be wound round and round a bobbin, and F J B 1 could never approach to doing that. He asked their lordships seriously to consider what the invention was, and as to minor details of insufficiency of specification he would endeavour to point out that they were as unworthy an attack on a specification as were ever made.

The learned counsel had not concluded his speech when the Court adjourned until Thursday.

(Continued on page 227.)

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, DECEMBER 20.

ELECTRIC LIGHTING.

Mr. WATT asked the President of the Board of Trade whether the Electric Lighting Act of 1882 precluded the Board of Trade or local authorities from granting licenses to one or more persons, firms, or companies to light the same area; whether the Act contained restrictions as to the breaking up of any street without the written consent of the Board of Trade; whether inquiries are made by the Board of Trade as to the ability of undertakers to carry out the work before licenses are granted; whether he could state what number of licenses had been granted since the last return was issued; and whether it was a fact that the reason assigned by companies which obtained licenses under the Act of 1882 for abandoning these was the enormous law costs which would have been incurred owing to the opposition of the local boards or councils.

Sir M. HICKS-BEACH: The Electric Lighting Act, 1882, does not preclude the granting of licenses to one or more persons, firms, or companies to light the same area. With reference to the second question, the Board of Trade cannot give power to break up streets except under a license or provisional order. As regards the third question, inquiries such as those suggested by the hon. member are made by the Board of Trade. Two licenses have been granted since the last report to Parliament. In reply to the last part of the question, I have to say that no such reason as that referred to by the hon. member has, to my knowledge, been assigned for the abandonment of licenses.

Mr. ROWNTREE asked the President of the Board of Trade whether his attention had been called to notices given for supplying electric light in the parish of Kensington, under the Electric Lighting Acts 1882 and 1888, by the four following companies, viz., the Kensington and Knightsbridge Electric Company (Limited), the Chelsea Electricity Supply Company (Limited), the Notting-hill Electric Lighting Company (Limited), and the House-to-House Electric Supply Company (Limited); whether he was aware that the said companies proposed to conduct their operations mainly, or very largely, within the same area, and in many instances to take power to break up the same streets, roads, or places; whether it was the duty of the Board of Trade, before making any provisional order, to take cognizance, of its own motion, of such *primâ facie* objections; and whether the Board would not take any cognizance unless and until it was moved thereto by the local authority, or other parties interested.

Sir M. HICKS-BEACH: The answer to the first three questions of the hon. member is "Yes;" and the answer to the last is, that it is the duty and practice of the Board of Trade, in framing a provisional order, to consider any objections to which their attention is called, and also any such as may occur to them.

Society of Arts.—On Wednesday evening, January 2nd, at 7 o'clock, Prof. Henry E. Armstrong will give the first of his two juvenile lectures at the Society of Arts, entitled "How Chemists Work: an Example to Boys and Girls

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The Electrician.

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For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
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„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
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THE DIRECTORY FOR 1889 IS IN PREPARATION.

CONTENTS OF THE CURRENT NUMBER.

Notes 211
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 216
Dynamo Regulation by means of a Third Brush. By Edward Caldwell, A.B., M.E. Illustrated 217
Legal Intelligence—
Edison and Swan Electric Light Company *v.* Holland and Others ..... 219 & 227
Watt *v.* The Maxim-Weston Electric Company — The Maxim-Weston Electric Company *v.* Watt 227
Parliamentary Intelligence 221
Christmas Greetings 222
Galvanised Iron Line Wire 223
On the Existence of an Undulatory Movement accompanying the Electric Spark. By Ernest H. Cook, D.Sc. Illustrated 224
The Puydt Arc Lamp. Illus... 226
American Notes 228
Correspondence—
The Mutual Action of a Pair of Rational Current Elements.—Oliver Heaviside. Illustrated 229
Electric Traction.—A. Reckenzaun 230
The Berners-street Mishap.—F. Higgins 231
Mr. Atkinson's Book on "The Elements of Electric Lighting."—Philip Atkinson ... 231
Patent Record 232
Books Received 232
Companies' Meetings, &c.—
Metropolitan Electric Supply Company (Limited) 233
London Electric Supply Corporation (Limited) 234
Maxim-Weston Electric Co. (Limited) 237
Charles L. Baker and Co. (Limited) 237
City Notes, &c. 237
Companies' Share List 238

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CHRISTMAS GREETINGS.

It has long been the custom of this journal at Christmastide to offer good wishes for the year that is to come, often, however, with small encouragement from the events of the year that was just expiring. No such check to our hopeful view of the immediate future has occurred during the past twelve months, and we can face the New Year with a cheerful confidence which it has rarely been our good fortune to experience. That our readers will share these sanguine anticipations we have very little doubt, and that they have good reason for doing so will be made plainer before we have concluded our review of the year 1888, as we hope to do in the course of the next two or three weeks.

Last Christmas we took for our text the proceedings of the Bradford Corporation with reference to the lighting by electricity of that important industrial centre, marking, as the incident did, a clear and decisive advance in the growth of electric lighting industry. At that time the Act of 1882 had not been amended, and its prospects in the ensuing Parliament remained still in uncertainty. The local authorities determined, notwithstanding, to establish the new light, and their discussions were characterised by an intelligence and sound judgment which augured well for the competence of such bodies to deal with the subject whenever it might be taken seriously into consideration. Since that time numerous municipalities have either followed the example of the Corporation of Bradford or have accepted independent proposals to establish central lighting stations, and on the whole there is much reason, so far,

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to be satisfied with the general result. In still more numerous instances the question has been under discussion, and where it has been debated without partisan bias, or the opposition of some vested local interests, it has met with a candid and even cordial reception; and where its opponents have carried the day it has evidently been in the face of an advocacy before which they will sooner or later have to yield.

If we were in need of another text for this present Christmas, the installations now in progress at the West End of London would afford an even more encouraging topic for comment. Under the impetus, or rather with the removal, of restrictions, afforded by the passing of the Electric Lighting Amendment Act this year, a number of provisional orders are already being proceeded with, and a great portion of what may be called the best part of the metropolis, including the West, West Central and Central areas, is being rapidly appropriated. Although the decision has come rather late, the Board of Trade have been well advised in declining to grant licenses for the metropolitan area. Complications with the local authorities will thus be avoided. Details of the schemes referred to need not be repeated here; but we may say in a general way that the selection of those districts seems to have been highly judicious for the purposes of a beginning. The localities just mentioned embrace the richest residential parts of London and the best of its shops. Whatever uncertainty may still remain as to the cost of electric lighting as compared with gas, there has never been any doubt about its superiority, or about the willingness of those who can afford it to pay for it as a luxury. If it succeed, as unquestionably it must, in the West, its extension to the East is only a matter of time.

In several other directions not affected by Acts of Parliament the electric light has been making great strides. To say nothing of private installations, which have spread beyond counting, its adoption on board the steamships of the Royal and Mercantile navies has become almost universal—so much so that as regards the former a new appointment has had to be made of superintending technical officer for electric lighting purposes to the Royal dockyards. In other public departments—notably in the Post Office—the same progress is visible, and probably will soon be followed by a similar step. The advance made in perfecting the machinery and appliances connected with this new industry has fully kept pace with its requirements; and under the stimulus of its activity, and the fuller experience gained by its extension, the best types of machinery are gradually being developed, and the manufacture of the lamps simplified and cheapened. These improvements will tend to make electricity a less expensive and more reliable agent in public lighting than it has yet been universally credited with being, and will speedily establish it in the position it is entitled to occupy.

Although the electric lighting business, from the magnitude of its operations, naturally takes a foremost place in our thoughts at present, it is very far from being the only electrical industry which offers subject for congratulation at this moment. Electric traction will soon no doubt make good its pretensions to compete with horse-power and steam; and in several other directions there are signs that electricity as a mechanical agent of great utility and handiness will soon find plenty of employment. Electric lifts and electric cranes are not, strictly speaking, novelties; but their practical application on any considerable scale may be said to be a new and encouraging feature of the times. A striking illustration of the unexpected developments which may be looked for in the near future is furnished by Prof. WHEELER'S electric fire engine, the power being obtained from a motor to be attached to the nearest electric light wire. We may rest assured that this is not the only mechanical use for which the current will be enlisted when the conductors are in full working order. The Telephone Companies have equally good reasons to be gratified with the progress they have been making and the position they have now attained in public estimation. Except, perhaps, in the manufacture of wire and apparatus for shipment abroad, electrical industries of all kinds in this country are vastly improved, and, with the general revival of trade which the highest authorities are agreed in predicting, the coming New Year presents a brighter countenance than she has assumed for a long time past. All this is good cheer, and it has, no doubt, contributed to help our readers to the enjoyment of a merrier Christmas than usual. We wish them also a happier New Year.

GALVANISED IRON LINE WIRE.

The iron wire which is now obtained by the Postal Telegraph Department for line purposes is of two qualities, known as low-resistance and high-resistance wire. The low-resistance wire may consist either of "special blend" iron, giving a mean resistance of 11·3 ohms per mile at 60° F. for the standard gauge of 171 millimetres; or of "charcoal" iron, giving under the same conditions a resistance of 11·2 ohms per mile. The high-resistance wire of the same gauge has a mean resistance of 12·7 ohms per mile.

As, owing to its high price, copper wire is not for the present to be supplied for the service, the low-resistance iron is employed wherever copper wire would otherwise be used; in fact, speaking generally, for all circuits exceeding 200 miles in length. High-resistance wire is employed for circuits not exceeding this length, but systematic use of copper wire for telephone circuits is still continued.

Both qualities of wire are about equal as regards tensile strength, which, as will be seen from the table given below, is somewhat greater than that of the wire hitherto supplied.

The following particulars relating to iron wire will often be of use:—

The relative resistances of pure copper and Swedish charcoal iron, similar to that used for the best line wire, are as—

$$1 : 6{\cdot}034,$$

or the resistance of commercial iron is 6·034 times that of pure copper, not 6·558 times, as usually given in text-books.

The specific resistance, or the resistance in absolute C.-G.-S. units of a centimetre cube at 60°F. is as follows:—

Silver	1609
Copper	1642
Pure iron	9753·5
Commercial iron.....	9907 (instead of 10,769).

From this it appears that iron wire may now be obtained having a conductivity of 98·44 per cent of pure iron.

When the resistance (r) of a sample of iron wire at t°F. is known, its resistance (R) at any other temperature t_1° may be found from the following formula:—

$$R = r\,(1{\cdot}0027)^{t_1 - t}$$

or, for degrees centigrade,

$$R = r\,(1{\cdot}0048)^{t_1 - t}$$

For example:

If a sample of wire has a resistance (r) of 10·99 ohms at 68°F., its resistance (R) at 86° may be obtained thus:

$$R = 10{\cdot}99\,(1{\cdot}0027)^{86-68} = 10{\cdot}99\,(1{\cdot}0027)^{18}$$

$$\log 1{\cdot}0027 = {\cdot}0011710$$
$$18$$
$$93680$$
$$11710$$
$$\cdot 0210780$$
$$\log 10{\cdot}99 = 1{\cdot}0409977$$
$$1{\cdot}0620757 = \log.\ \text{of } 11{\cdot}54$$

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GALVANISED IRON LINE WIRE.

Gauge No.	Weight per mile.	Diameter.	Breaking Weight.			Elongation per cent.			No. of Twists in 6 inches.		
			Low Resistance.		High Resistance.	Low Resistance.		High Resistance.	Low Resistance.		High Resistance.
			Blend.	Charcoal.		Blend.	Charcoal.		Blend.	Charcoal.	
	lb.	inch.	lb.	lb.	lb.						
4	600	·209	1,920	1,725	2,100	16-17	16-17	17-18	17	18	22
7½	400	·171	1,280	1,150	1,390	,,	,,	,,	23·5	25	30
10½	200	·121	640	575	695	,,	,,	,,	30	31	38

The required resistance is therefore 11·54 ohms.

1 foot-grain of pure iron has a resistance of 1·097 ohm.
1 metre-gramme of pure iron has a resistance of ..... 0·7654 ohm.
1 ohm-mile of pure iron weighs ..... 4368·94lb.
1 ohm-mile of low-resistance blend wire weighs ..... 4520 ,,
1 ohm-mile of low-resistance charcoal wire weighs ..... 4480 ,,
1 ohm-mile of high-resistance wire weighs 5080 ,,

and, knowing the ohm-mile of any iron wire (which is found by multiplying the weight in pounds per mile by the resistance per mile), we readily get the percentage of conductivity of that wire.

For example, suppose one mile of wire weighing 400lb. has a resistance of 11·2 ohms, then an ohm-mile will weigh—

$$11{\cdot}2 \times 400 = 4{,}480\text{lb.}$$

and its conductivity per cent. will be—

$$\frac{4368{\cdot}94 \times 100}{4480} = 97{\cdot}51.$$

The above table gives the mechanical qualities of iron wire.

ON THE EXISTENCE OF AN UNDULATORY MOVEMENT ACCOMPANYING THE ELECTRIC SPARK.*

BY ERNEST H. COOK, D.SC. (LOND.), F.I.C.

1. If a powdered substance be scattered over a smooth plate, and the plate held near a pair of terminals between which an electric spark is passing, the powder will arrange itself in a more or less regular series of concentric circles. The common centre of these circles (when the spark is small) appears to be a point directly under that halfway between the terminals. The general appearance presented by these curves will be apparent by a glance at the figures in the plate which accompanies this Paper. These are approximately of the same size as the original. It will be noticed that the figures roughly divide themselves into two classes—(1) those with a clear space in the middle, and (2) those with a circular space, within which the powder is apparently unaffected.

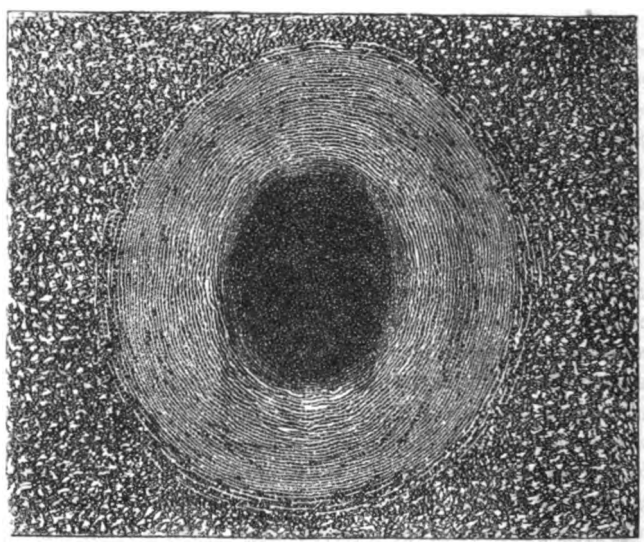
The first class are obtained by holding the plate near to the terminals, the distance varying with the energy of the spark. The cleared space is irregularly elliptical, with its major axis at right angles to the direction of the spark, and the area of the space increases as the intensity of the spark increases. The second class are formed when the distance between the spark and plate is increased until the elliptical space ceases to make its appearance.

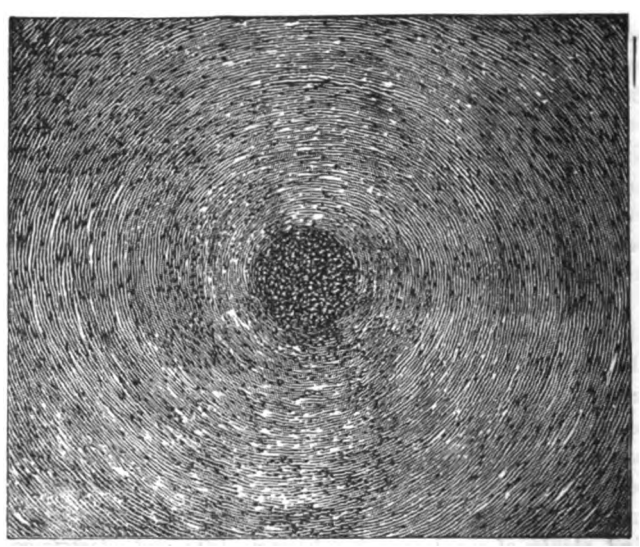
2. *Mode of Obtaining the Curves.*—The most convenient arrangement and the one which gives the best results is as follows :—An induction coil has each of its terminals connected with a Leyden jar, and with one of the handles of a universal discharger. The plate with the powder scattered over it from a sieve is held under the points at a distance which can be varied at pleasure. The distance between the terminals, and therefore the length of the spark, can also be easily adjusted. On connecting the coil to the battery a succession of sparks of condensed electricity is obtained, and the powders will be seen to arrange themselves in the manner described. The first spark causes a distinct effect, but a continuance is necessary to bring out the regularity of the curves.

Should it be required to fix the powders in the positions which they have taken up, it is easily done by coating the plate beforehand with a thin layer of gum, and after the experiment breathing on it.

* Read before the Physical Society, June 23rd, 1888. The Paper was illustrated by a series of photographs; from two of these the figures in the engraving have been taken.

3. *Effect of Plate.*—When the figures were first obtained it was surmised that they might be caused by the distribution of the electricity over the plate; that they were, in fact, modified Lichtenberg's figures. Experiments were therefore made with plates of various substances in different states as regards their surfaces; for example, whether polished or dull, electrified or unelectrified. The following materials have been examined :—Glass, resinous cake of electrophorus (a mixture of shellac, resin, and Venice turpentine), ebonite, paper (glazed and unglazed), brass (lacquered and unlacquered), zinc, iron, tinned ditto, galvanised ditto, wood, paraffin, cardboard, and glazed and unglazed earthenware. Except that the rougher surfaces retard and prevent the regularity of the curves, no difference whatever could be observed as due to the substance or condition of the surface.





A piece of plate-glass, or polished sheet of metal, answers admirably for these experiments. The fact that the production of the curves is independent of the electrical state of the support (and therefore of the powder) justifies the statement that they are not caused by any peculiarity of electrical distribution.

4. *Effect of Battery Power, Coil, and Condensation*—Experiments were made with the view of finding if variations in the number of cells, in the coil, and in the capacity of the condensers used, caused

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any alteration in the shape or frequency of the lines in which the powders arranged themselves. Other conditions remaining constant, the battery power employed to drive the coil was changed from ten-pint bichromates to one. In no case could any difference be observed in the resulting figures produced. Afterwards the current was still further reduced until it was just sufficient to drive the coil, but so long as this was accomplished the figures remained unaffected.

Several coils were used in the course of the earlier experiments, but finally the work was confined to two. One of these was a very fine instrument by Ruhmkorff, kindly lent to me for the purpose of these experiments by Mr. Francis J. Fry, late high sheriff of Bristol. It contains a secondary coil, formed of twenty-four miles of wire, is fitted with both spring and mercury interrupters, and with one bichromate (carbons 7in. by 3½in.) gives a regular succession of sparks 6in. long. The second was a smaller instrument, by Paterson of London, fitted with a condenser of 100 sheets of 12in. by 5in., and capable of giving a small spark of about 1½in. long. When coupled with the Leyden jars, of course, the length of spark was much diminished. In no case with either coil was a longer spark employed than ·75in. No change in the appearance, regularity, or shape of the figures was caused by replacing one coil by another.

The effect of a difference in condensing-power was tried by interposing more jars. Except that the vigour of the spark caused a larger area of cleared space, no alteration could be observed. This is, of course, confirmed by the fact of the different coils, possessing condensers of different areas, giving identical results.

5. *Influence of Contact-Breaker.*—It might be supposed, as was done by Grove in reference to the stratifications in partial vacuo, that the intermittent character of the currents flowing in the secondary wire caused by the interruptions in the primary-coil by the contact-breaker would have some influence in producing or regulating the curves. This, however, is not the case. The shapes did not alter no matter what coil was employed, and when the mercury-break on the large coil was used in place of the spring no alteration in the resulting curves was produced. Moreover, the curves can be obtained without the use of a coil with its necessary contact-breaker at all. For this purpose it is only necessary to connect each electrode of a Wimshurst machine to one or two Leyden jars, and to allow the highly condensed spark thus obtained to act upon the powder; in fact, I have been able to produce the curves in this way without employing any jars at all. With the machine, however, they are far inferior in regularity to those produced by the use of the coil. With a 17in. plate the best results have been obtained with jars having a total area of foil of about 1,500 square inches, a spark of about 3in. long, and the powder 6in. below spark.

6. *Nature of Electrodes.*—Varying the material forming the points between which the sparks were taken made no difference in the resulting shapes. Thus the same effects are produced by using brass, iron, or carbon points.

7. *Influence of the Powdered Substance.*—Soon after the first results were obtained, and upon trying different substances, it became evident that, although accidental irregularities occurred, yet, upon the whole, the curves were remarkably regular. It was also very soon noticed that the frequency with which they followed each other altered with an alteration of the substance of which they were composed. This induced a desire to compare by measurement the distances between each successive curve. A large number of different powders were examined, and the number of lines in a certain distance counted. Several determinations were made and the mean number taken. Although every care was taken to make these measurements as accurately as possible and to avoid sources of error, yet, from the difficulties peculiar to the case, I do not wish to pledge the absolute accuracy of the numbers, but put them forward as approximate only. It first became necessary to ascertain if the fineness of the powder affected the number of lines in a certain length. This was found not to be the case. Provided the degree of fineness was such as to admit of the production of the lines with such an amount of definiteness as sufficed for their measurement, the number of lines was found to be unaltered. The following tabular statement gives the results obtained. The actual experiment was to count the number in a quarter of an inch. These have been multipled by 4, hence the regularity of the diminution of the numbers given in the first column:—

No. of Lines in 1 inch.	Substances Examined.
88.	Silica (powdered sand).
80.	Magnesia alba.
68.	Chromic oxide.
64.	Antimony sulphide; baric peroxide; fluor spar; cupric oxide; red lead; lead acetate; lead oxide; antimony; sulphur; potassium hydrogen tartrate.
60.	Borax; cobaltic oxide; starch; zinc carbonate.
56.	Binoxide of manganese; baric carbonate; tricalcic phosphate; ferrous sulphide; lead chromate; mercuric oxide; binoxide of tin; nickel monoxide; lead carbonate; calcic oxide.
52.	Sodium hydrogen carbonate; potassic sulphate; potassic carbonate; mercurous chloride; carbon; calcic hydrate.
48.	Tannin; salicylic acid; rochelle salt; ammonic sulphate; baric nitrate; copper sulphate; oxalic acid; sodic chloride succinic acid; Epsom salts.
44.	Alum.
40.	Chalk.
The figures were so indefinite as not to permit counting.	Iron filings; baric chloride; baric sulphate; benzoic acid; strontium chloride; bismuth nitrate; cadmium nitrate; microcosmic salt; potassium chloride; potassium bromide; ammonium chloride; ferrous sulphate; ammonium nitrate; pyrogallol.

8. *Effect of Mixture.*—While engaged in repeating the experiments, in order to confirm the numbers, it was found that a particular sample of calcic oxide gave 48 lines to the inch instead of 56, as given in the table. Upon examining the sample it was found, however, to be an old one, and to be partially converted into carbonate. It was thus a mixture of oxide and carbonate. This led to the investigation of other mixtures. It was thus proved that the number given by a mixture of two substances was intermediate between those of its constituents. The following were examined, no particular care being taken to mix in definite proportions, but the substances simply ground up together in a mortar:—

Mixture.	Nos. due to each constituent.	No. obtained.		
		Exp. 1	2.	3.
Calcic oxide	56	48	50	48
Calcic carbonate	40			
Magnesia alba	80	60	64	56
Calcic carbonate.....	40			
Cobaltic oxide	60	64	64	66
Chromic oxide	68			
Cobaltic oxide	60	68	64	68
Magnesia alba	80			

9. *Effect on Liquids.*—In order to test if the effect could be produced on the surfaces of liquids the following experiments were made:—In place of a glass plate with the powder scattered over it, there was held under the spark a shallow vessel (an ordinary porcelain evaporating dish answers very well) containing the liquid. So long as the surface was looked directly down upon, no effect could be observed; but when regarded obliquely, minute ripples were seen to be produced upon the surface. No attempt was made to measure these, but they were judged to be of about the same size as those of the powders—that is, between the limits of 88 and 40 to the inch. The following were the liquids tested in this way:—Water, mercury, alcohol, ether, glycerine, and benzol.

10. *Experiments with Wimshurst Machine.*—It has already been stated that the curves obtained by the aid of the machine are much inferior in regularity to those given by the induction coil; in fact, without care they cannot be produced at all. But there are some other peculiarities which deserve notice Thus, while with every coil used, and with varying battery-power, it was found that magnesia alba gave 80 lines to the inch, when the machine was used the number varied in different parts of the figure from 56 to 64. There was no particular mode of variation—that is, no crowding together at a special place, &c. This irregularity in the numbers is not, however, a general thing, for in other cases tried the numbers did not vary among themselves and agreed with those obtained with the coils.

The common centre of the circles, instead of being, as with the coil, half way between the terminals, seemed to be a little nearer the positive electrode than the negative. Other experiments are, however, necessary before this can be regarded as established.

In experimenting with this machine it is necessary to avoid placing the plate too near the terminals, otherwise the powder becomes electrified, and the plate also, and the resulting figures are combinations of those showing the distribution of the electricity upon the plate, and the undulatory effect discussed in this Paper.

Most of the figures obtained with the machine were caused by the spark passing between knobs. They are imperfect at the sides in consequence of the undulatory effect being prevented from making itself felt in those directions by the solid body of the knob coming between. Thus the portions of the circles shown are at right angles to the direction of the spark. The figure can of course be obtained from sparks taken between points, but it is more difficult. It was particularly noticed in the course of these and some other experi-

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ments that, whilst substituting a knob for a point in a Wimshurst or other machine increased the length of spark obtainable, it was just the opposite with a coil, for here the spark is considerably reduced if taken between *two* knobs. The longest spark with a coil is obtained either between two points, or between two points, or between one point and one knob or plate.

It was also noticed that under the positive electrode the powder was scattered so as to cause a space. This is sometimes, but not always, the case under the negative.

11. *Production of the Cleared Space.*—It will be observed that the more or less elliptical space in the middle of the figures is not present at all. It is only produced when the plate is held close up to the terminals, and when the vigour of the spark is considerable. At a first glance at a figure containing the clear space, it appears that the lines are crowded together at the ends of the major axis of the ellipse. Closer examination and careful measurement will show, however, that this is not the case, for the number of lines per unit of length is the same whether measured at the ends of the major or of the minor axis; in fact, the appearance is just that of concentric circles, formed of the powder, with the material composing the smaller circles swept up so as to form the irregular ellipse.

From this fact, and also that the circles can be produced without any clearing of the powder, I am led to conclude that the production of the circles is due to *an entirely different cause* to that producing the space, but that both are necessary accompaniments of the disruptive discharge.

12. *Discussion of Results.*—When these figures were first obtained it was imagined that they were due to the sound which accompanied the spark, and in fact gave a graphical representation of the sound-waves. This view was to some extent confirmed by finding that the same substance gave the same number of waves in the same space. If this be so, however, then there ought to be no difference in the numbers obtained with different powders; for the sound of the spark produced by a coil is remarkably constant, and, if such a term can be rightly applied to it, it is of unvarying pitch. This view, however, is also disproved by the measurements; for if it be taken that the lines show the phases of the undulatory movement, then the longest distance between similar phases is that given by powdered chalk, viz. $\frac{1}{40}$ of an inch. But the upper limit of vibration producing a sound-wave may be taken as equal to 40,000 per second, giving a length for the wave of as nearly as possible one-third of an inch, a distance thirteen times greater than the longest given by these experiments. It is therefore evident that the vibrations producing these curves and those producing the sound of the spark are not identical.

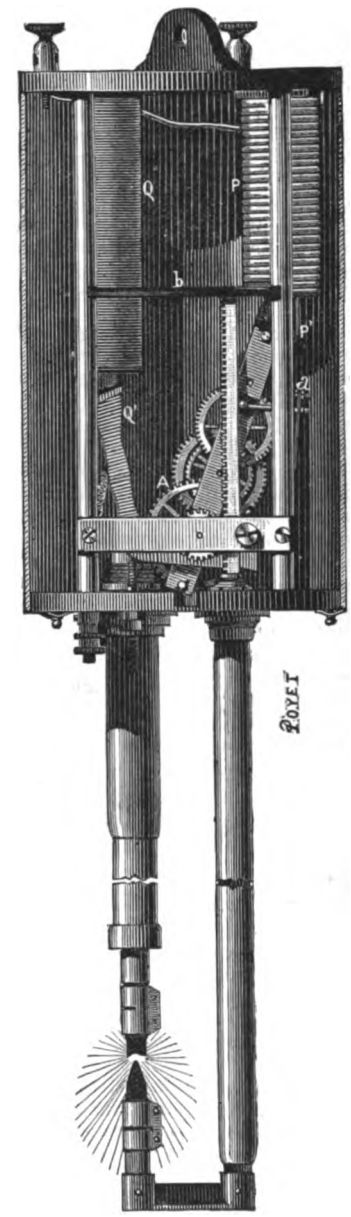
From the fact that the number given by a mixture is intermediate between those of its constituents, we should be led to conclude, since the density of a mixture follows the same law, that therefore this is the factor which regulates the number given by any particular substance. If this be the case, then the powders should arrange themselves in a series, with those of the highest density at the top and those of the lowest at the bottom. A glance at the tables of results will, however, show that no such order is observed. Thus we have silica giving a higher number (88) than the heavy oxides of lead (64); magnesia alba, a substance of very low specific gravity, appearing high up in the list; and tannin, also of low specific gravity, on the other hand, appearing low down. What conditions, if any, regulate the number of these lines I have hitherto been unable to determine. Before any generalisation can be made it is necessary to examine a very much larger number of substances, and experiments are being conducted with this purpose. At present, indeed, I am not disposed to attach much importance to the absolute length of any one of these undulations, but rather to the great similarity of the measurements as a whole. For although it is likely that errors may occur in some of the individual members, it is hardly possible that the whole are erroneous. It will therefore follow that undulations of a length of about one sixty-fourth of an inch (taking the mean measurement) accompany the disruptive discharge.

The photographs from which the figures in the plate are copied were taken for me by Mr. Dunscombe, of Bristol, and were printed from the negatives without the latter being touched in any way.

Note, June 9, 1888.—Since the above was written, I have been informed by Prof. Rücker that he has an apparatus in his possession, made by the late Dr. Guthrie, which gives somewhat similar results. This was copied from one exhibited at the Loan Exhibition of scientific apparatus in 1879. It consists of an elliptical dish with vertical walls. Sand is scattered over the bottom, a glass plate placed over the top, and a series of electric sparks produced at one focus of the ellipse. The sand will then be found to arrange itself in a series of circular curves around the other focus. The curves thus produced bear a striking resemblance to those exhibited in the plate accompanying this Paper, and are of course due to the same cause.

THE PUYDT ARC LAMP.*

In this apparatus the descent of the rod of the upper carbon holder supplies the motive power. This rod gears into the wheel A, which forms the first of a series of toothed wheels mounted on an oscillating frame. The upper end of the lower carbon holder gears into a second wheel, which is on the same axis as A. These two wheels are so proportioned that the arc remains fixed while the lamp is in operation. The striking of the arc is effected by means of the electro-magnet P, which is in series with the arc, and which acts upon an oblique armature P', connected to the frame of the



The Puydt Arc Lamp

clockwork; P', when attracted by the electro-magnet, causes this frame to revolve round its lower axis, thus forcing the carbons apart. The length of the arc is regulated by the electro-magnet Q, which is a shunt upon the arc, and whose armature Q' is fixed to an U-shaped lever, revolving upon the same axis as the frame of the clockwork. This lever terminates in the brake *a*, which clutches or frees the last wheel of the series. An easily regulated spring brings the lever back to its normal position whenever the current is interrupted. This lamp is made by M. Jaspar, of Liège. Its mechanism is more simple than it appears to be from the description, and good results are obtained in practice.

* Translated from M. Hippolyte Fontaine's "Eclairage à Electricité" by kind permission of the Author.

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Edison and Swan Electric Light Company v. Holland and Others—(*Continued from page 221*).

THURSDAY, DECEMBER 13.

The ATTORNEY-GENERAL resumed his address, and, handing the 500 candle-power lamp to their lordships, pointed out that it had two small wires run through instead of one, and said that as long as Swan and Stearn used thick wire they had fractures.

LORD JUSTICE LINDLEY: As I understand you, if you have these thin wires you can be quite indifferent about the glass?

The ATTORNEY-GENERAL: Quite so. One installation at Middlesborough was the only one referred to by a witness as being run in series; and their lordships would not forget that Mr. Justice Kay had founded his decision on the assumption that series was as useful as multiple arc lighting. The transformer system, as far as this trial was concerned, had no existence. Further, Sir Frederick Bramwell had said with regard to the F J B 1 that the pencil in that had been made after carbonisation, that it was a lamp of extremely low resistance, and therefore unable to accomplish what Edison's lamp did. In 1880 some lamps were sent over by Mr. Edison and placed in the hands of the scientific adviser of the Edison Telephone Company. These were run off galvanic batteries in a room in Queen Victoria-street, being arranged in parallel. Those lamps were exhibited during some weeks, and the only cross-examination upon that was to the point that those were made under the December specification. When he came to deal with the question of the November specification being sufficient he should submit that it was immaterial under which specification they were made. The whole strength of Edison's case was that the defendants could not grapple with the question really, but were obliged to try to fritter it away bit by bit. Even Lane-Fox—a man of great ability in the matter—had used asbestos and other things; and again could be seen the courage of Edison's step in saying, "Take a thread for your carbon and the problem is solved."

LORD JUSTICE LINDLEY asked why F J B 1 was not an infringement?

The ATTORNEY-GENERAL replied because the filament, if it could be so called, was not capable of being twisted. It was an abandoned experiment, and *nihil ad rem*. Continuing, the learned counsel said that he had shuddered (laughter) at one of Mr. Finlay's statements as to tar-putty lamps being worthless, because they did not run any appreciable time, but Mr. Gimingham had made, long before Crookes's experiments, lamps that would run for 150 hours.

Mr. FINLAY: Not those made in the first instance.

The ATTORNEY-GENERAL said it was before Mr. Gimingham was recalled, and long before Mr. Crookes's experiments took place. These lamps were run, but Sir Horace Davey said, "These may be very good lamps, but we are not satisfied they were made according to the specification."

Mr. FINLAY said that it was not until after the cross-examination of their witnesses, at a later stage of the case, that they found out how to do these things.

LORD JUSTICE COTTON said he thought that there was no question about any cross-examination as to the amount of pressure, but he thought that Mr. Finlay had suggested that it had been found out after the commencement of this trial, by experiment or otherwise, that considerable pressure must be used with tar putty filaments.

The ATTORNEY-GENERAL said he would argue that point upon the specification presently.

Mr. FINLAY: Show a single question put by you in cross-examination upon it.

The ATTORNEY-GENERAL said that this was not quite fair; his point was an entirely different one. There were in existence lamps sworn to be made four years before for the Woodhouse and Rawson trial—and if there was any suggestion that those were not useful lamps, why was it not asked to have them run? Boys and girls made those lamps, and it was ridiculous to suggest that they had skilled instructions given them. As to the time occupied in making the tar putty filament, his opponents and Mr. Justice Kay relied upon it being an hour and a-half. The man Plum, of course, would be desirous to work so as not to break down, and took on the first occasion one hour and ten minutes. Now Prof. Stokes had stated that subsequently it was done much more quickly, he taking the time in the presence of Prof. Thompson, and on the other occasion it took seventeen minutes. It had to be rolled out to $\frac{7}{1000}$ part of an inch.

LORD JUSTICE BOWEN: It is the making of the putty that takes twenty minutes, not the rolling.

The ATTORNEY-GENERAL said they were working for a filament, using tar and lampblack, and he asked their lordships to consider the elements of failure. Of course there must be such homogeneity that there would be no piece of lampblack sticking out; if there were a piece not worked in it would come off, and there would be a hole in the filament. His opponents seemed to think that when they had got the putty they had not to go on and make it homogeneous. (The specimens of the putty sent by Prof. Stokes to Mr. Justice Kay and specimens of the materials used were here handed to their lordships.)

Mr. GRAHAM said that the first day he went he noticed that it was done with a great amount of time and labour. That was considered so important that he wrote a memorandum and gave it to Prof. Stokes, and it opened their eyes for the first time to the secret.

LORD JUSTICE COTTON: What we want to know is the fact of the time.

Mr. GRAHAM; Plum set to work next time, and used a much larger amount of energy, and did it in 17 minutes.

Mr. FINLAY: The point is the amount of force—greater force used in a shorter ime.

The ATTORNEY-GENERAL said he would ask their lordships to take the exact parallel of kneading dough. Assume that there were no agglomerations in the dough, assume that Plum worked harder when he did it in the shorter time, and he submitted that this was the most trifling special pleading ever known. The kneading was to be done properly, so that there remained no infinitesimal pockets of lampblack; but it was now contended by his opponents that, because the time of the kneading and the strength to be used were not shown, the patent was incomplete. Suppose the putty broke when rolled out to $\frac{7}{1000}$ part of an inch, could it be said that it had been properly kneaded? Prof. Stokes in his report said that the proper condition of the tar putty was deemed to have been attained, and the required consistence attained as judged by comparison with common putty. He asked their lordships if that was fair? No. It must be tried to be rolled out to do the work the specification said. The experiment was tried in such a way that it must fail. In the next case the report said "a little more lampblack had been added, in this case about a minute and a-half before finishing." He asked their lordships' particular attention to that—they had been working at it for nearly sixteen minutes, and then they added more lampblack. A portion of the putty rolled between the thumb and finger cracked and blackened the fingers; and yet these professors took and used a putty which blackened the fingers and cracked at the ends. It was not properly mixed. Then the report said, "the roll of tar putty on being squeezed became shiny on the suaface, indicating the oozing out of a part of the mixture," and this was said to be a proper mixing of putty that was to be rolled out to the $\frac{7}{1000}$th part of an inch! "An attempt was made to roll it," and the material would not hold together. The respondents contended that this kneading was not properly known until these experiments. How, then, did Prof. Dewar make filaments which would burn? The answer was, that if you tried to work as the specification directed it would do, and if so as to make it fail, it would fail.

LORD JUSTICE BOWEN said he could not help feeling that that would be a fraud.

The ATTORNEY-GENERAL said he considered that Mr. Crookes's evidence was not fair. Water had been used to moisten the putty, and no chemist would have used water. Of course, tar putty could be rolled out, but his learned friends were contending that it ought to be done without even practice. (Specimens of the tar-putty were here handed to their lordships.) The inventor, the Attorney-General contended, was under no obligation to put in the time of the operation. Frankland had produced a filament for the Woodhouse and Rawson trial—it was a Pulvermacher, and that witness in this trial had expressed his surprise at Crookes's failure.

Mr. FINLAY observed that Mr. Justice Kay had said that he had reason to believe that Prof. Crookes carried out the experiments satisfactorily.

The ATTORNEY-GENERAL said that these facts were not before Mr. Justice Kay, and he believed he should show their lordships that the experiments were not as fair as they might have been. Mr. Finlay had said that they only found out about the tar putty after the defendants' evidence had begun, but their lordships would find in Gimingham's evidence there had been no cross-examination as to inability to make the tar putty. Gimingham was called on the 19th of April; the experiments before Prof. Stokes took place on the 11th of June.

LORD JUSTICE COTTON: Does Mr. Finlay say that Gimingham never made tar putty lamps; or that, having made them, he never ran them for duration?

Mr. FINLAY: That he never ran them for duration before this case.

The ATTORNEY-GENERAL said that the secret instructions were nothing more than to knead longer. He asked on what ground was there a failure when the lamps had been proved to burn? In other experiments tar and plumbago were used when tar and lampblack ought to have been, as the specification said distinctly plumbago had silicon in it, which was fatal. As to the iron box used, it was alleged that its size ought to have been in the specification. There was nothing in the use of a small box in place of a large one. The one used was said to fit carefully, but it was agreed that it was common knowledge to pack things to be carbonised with charcoal. Why were filaments to be excluded from that common knowledge? What was the outcome of the attack in the specification? The E G lamps were proved to have been made by Gimingham, and the defendants never examined him as to the impossibility of making one of these lamps. Mr. Justice Kay had said that it was agreed that, if charcoal packing were used, there was no difficulty in the carbonisation. This point of defence was an afterthought. Prof. Stokes stood as a referee, and reported in favour of Edison's experts, and gave reasons for the failures. The Attorney-General asked their lordships to say that the attack on the specification had failed. Tar putty, Mexican fibre, a splint, lancewood splints, and so on—all tried, and not a failure amongst them. Was it a great combination, or was it not? It was as great as any of the very marvellous inventions of Mr. Edison. He asked their lordships to say that F J B 1 was an abandoned experiment. In Edison's specification first appeared the use of the word filament, and he submitted that the appellants were entitled to judgment on appeal. If that were so given he should ask their lordships to hear him as to the form of the order.

Their lordships reserved judgment, it having been arranged for the exhibits to be placed in a room where their lordships could have access to them.

Watt v. The Maxim-Weston Electric Company—The Maxim-Weston Electric Company v. Watt.

On Thursday in last week Mr. Watt, late managing director of the Maxim-Weston Electric Company, made a motion to commit Mr. John Marks to prison for contempt of Court in having made certain statements in a speech delivered at a reconstruction meeting of the company held on the 3rd inst. Mr. Marks was chairman of the meeting. The ground on which the motion was made was that the statements related to the matters in dispute in the

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legal proceedings pending between Mr. Watt and the company, and tended to prejudice a fair trial. It appeared that a shorthand writer was employed by the directors of the Company at an expense of five guineas to take down what happened at the meeting, and the proceedings were reported, and the obnoxious statements appeared in the report in the *Financial News* and *The Electrician*, and as many as 1,800 copies of the former paper were purchased for distribution by the directors of the company, for which £7. 10s. was paid. The words complained of as reported in the *Financial News* were as follows :—

"He said deliberately that the last balance-sheet Mr. Watt issued to the shareholders was absolutely false. It showed a false profit, on which Mr. Watt had taken 5 per cent. commission. Not only that, but there were sales entered in the books as *bonâ fide*, and which they found were bogus sales, large profits arising from these being shown on the books, but on which in reality the company made a serious loss. Mr. Watt had taken 5 per cent. commission on these. It was Mr. Watt's management, or rather mismanagement, which had brought them to their present position."

Mr. Marks in his evidence asserted that the report was not absolutely correct, inasmuch as he had not charged Mr. Watt with taking, but only with claiming the 5 per cent. commission; but in this his lordship considered Mr. Watt mistaken. At the beginning of his speech he had himself explained that he intended to refrain from going into the matters in dispute because the legal proceedings were pending, and it was in answer to questions, he said, that he was drawn into making the statements complained of, and he claimed privilege. —Mr. Napier Higgins, Q.C., and Mr. George F. Hart appeared for Mr. Watt in support of the motion; Mr. Cozens-Hardy, Q.C., and Mr. Gazdar, for Mr. Marks, opposed. —Mr. Justice North considered it was not a case in which the respondent should be sent to prison, but he did consider it a case in which he had transgressed the rule of the Court, which required parties to abstain from publishing matter tending to obstruct the course of justice. He said that, though Mr. Marks had not himself ordered the employment of the reporter for the purpose of publishing the proceedings at the meeting, he was one of the directors who had acquiesced and was responsible. With respect to the defence of privilege, if it were the case that Mr. Marks would have been justified in making the remarks to his own shareholders in response to inquiries, that did not apply to the publication to the world in the newspapers, and it was not like a case where the remarks got into the newspapers without authority. He therefore ordered the respondent to pay the costs of the motion.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 15th*, 1888.

We have had during the past week another series of experiments by Mr. Harold P. Brown, and the medical men previously associated with him, with regard to the effect of currents of electricity on animal organisms. You will remember that Mr. Brown recently rendered himself quite famous by his experiments on several dogs with direct and alternating currents. At that time, although the alternating current proved very effectual with the dogs, the question was naturally raised in some quarters whether it would be as effective with bigger animals. The heaviest of the dogs weighed only about 90lb., and it was argued that a greater E.M.F. would be necessary to kill a human being. This new series of experiments was conducted at Mr. Edison's laboratory, and in this case the horse it was that died. It appears that with the main current of an alternating machine at 770 volts the mare and the two calves experimented upon died immediately, the death being painless, as well as instantaneous. It may be mentioned that the mare, with the halter, weighed 1,230lb.; she had a dislocated hip, but otherwise is reported to have been in good condition. It was first tried to perform the experiments by making the connections around each fore leg, in order to approximate to the condition that would obtain with a criminal held in metal wristlets; but it was proven that the head and spinal column were much better points of application for the purpose of electrical execution. What gave importance to this series of experiments, besides its bearing on the use of alternating currents, which, perhaps, is not a slight one, is the fact that electrical executions are called for by law on capital sentences after January 1st. The Medico-Legal Society of this city is to take up the question this week, at its annual meeting, when reports and Papers on the subject will be presented. In the meantime, I may as well say that I find a not remarkable absence of interest in the subject on the part of electricians, and I think if our profession here were polled it would be found that a large majority would vote against the use of electricity for death-dealing purposes.

It looks as if urgency were to be given to the big suit of the Government against the American Bell Telephone Company. Mr. Jenks, the Assistant-Attorney-General, has, on application, caused a mandate to be issued by the United States Supreme Court to the Massachusetts Circuit Court, informing the latter tribunal of the decision against the Telephone Company. It appears that the mandate of the Court would, in the ordinary routine, have been issued after the February recess; but in order to hasten the trial of the case on its merits, it has now been specially issued. With regard to the object of the Government in the matter, Mr. Jefferson Chandler, of St. Louis, one of its counsel, is reported to have said that, in spite of this urging of matters, he does not think they can get to the trial point under six months. In that event the question, if tried at all, would be tried under the direction of the new Attorney-General of the Republican Administration. The general expectation is, from the fact that the litigation has been one of the scandals of the Democratic Administration, that the incoming Republican President and Cabinet will care to have nothing whatever to do with it, and will drop it at once. No declaration has yet been made as to the probable policy of President Harrison in regard to this question; but it is safe to assume that he will be well pleased to let the case alone, even although he should be liable to the allegation of having been influenced by the Telephone Company.

The city of Boston is just now interested in an agitation which has been started by some citizens to reduce the cost of electric lighting. There has been quite a controversy in the newspapers on the subject, and it would appear from the electrical papers this week that one of the main points of the agitators has been the lessened cost of the carbons. It has been incidentally brought out that when the company that now does the lighting had its contract from the city in 1882 carbons were costing at the rate of $120 a thousand, or sixpence each. Now, however, carbons are down to from $10 to $15 a thousand, and the Bostonians think they ought to have the whole benefit of that reduction. But, as has been pointed out here, the price of carbon is only one element in the matter. For instance, since 1882 there has been a tremendous jump in the copper market, and the consequence is that conductors, looking at the copper alone, cost more than they did five years ago. In addition to that, the conductors have to be more fully and perfectly insulated, and there again additional expense comes in; while, in many instances, the companies are put to the further cost of labour in regard to underground experiments, which but too often prove failures. Hence it is evident that there is a great deal more to be taken into consideration than the mere current market value of the carbon points to trim the lamps with. Reference has also been made by the leaders in the Boston movement to the fact that in 1887 several extraordinary low bids were made for electric lighting in New York, but Mr. Gilbert, the president of the Boston Company, points out that not only was that a season of merciless competition, but that several companies then bidding had an existence only on paper, so that the companies in possession of the field took low contracts, not because they were fair, but because they were at that time vital to their existence. Mr. Gilbert might have added, too, that those low contracts in New York lasted but a year, since when prices have been much better, and are likely to go even higher. I mention this fact because it is typical of movements that have been going on in other cities, and which are, in a way, expressive of the general desire to obtain more electric lighting without paying more for it. In several cases the cities have themselves been conducting an investigation into the matter, and have convinced themselves that it would be better for them to buy plants of their own and run them. There would undoubtedly be shown a saving to any city by the adoption of such a plan, because the city would be cutting off the profit which the company naturally expects in its investment; but, on the other hand, I am not aware that it has yet been found on the whole, and in the long run, in this country, wise for a city to conduct such industrial enterprises, which hardly seem to come within the same catagory as water supply or the building of harbours, and are greatly liable to the adverse influences of political picking and stealing.

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A rather interesting little article appears in one of the papers this week on the subject of stock tickers and their patrons. As you are probably aware the ticker is a great institution in this city. The average "down town" New York broker does not seem happy unless he is within earshot of the little instrument, and one of his favourite amusements is hanging on to the end of the tape as it slowly reels off, or else drawing out a few miles of it from the basket, and tangling himself up in it. The article I refer to mentions an amusing case of a Wall-street devotee who had been in the habit of hanging over the tape all day long, and who, as the result, was soon worried into a state of nervous prostration. He was placed by the doctors in a quiet room at his hotel, but did not get better, and was afterwards moved again to an even quieter asylum. But there his nervous ailment instead of slackening became greater, and all the doctor's efforts at cure were futile. One day, however, it struck the doctor that there was always a pretty big bank of pillows at the end of the bed, and he began to re-arrange them, whereupon the patient protested vigorously. The pillows were tumbled off, however, and there was revealed to view, clicking away, a regular everyday ticker. It had been smuggled into the room and set going for the special benefit of the invalid? There are now some 3,000 of these tickers in New York city alone, and an idea of the work that they do may be formed from the fact that the business of the Stock Exchange, which constitutes the bulk of their reports, will often run to three or four hundred thousand shares a day, so that an operator, to get the quotations promptly from the floor and send them out to the main ticker office, will have to be capable of receiving and sending the number of shares and prices of from twelve to fifteen different shares of stock in one minute, which means making legible characters at the rate of 115 every 60 seconds during the busy hours of the day. The privilege of reporting on the stock, produce, cotton, and other exchanges has been warmly contested for. For a long time the Stock Exchange work was considered a perquisite of the Gold and Stock Telegraph Company, which is owned by the Western Union Company; but of late years the Commercial Telegram Company has obtained a footing, and under the decision of the United States Supreme Court, just rendered, the Stock Exchange is enjoined from expelling from its floor the Commercial Telegram Company, so that if one set of tickers is thrown out the other must go too. It has been proposed three or four times on the exchanges to keep the quotations made there as private as possible, but it is not likely that this will ever become law, as the public is much too deeply interested in the current prices of stocks to hand over its money in that way to the Star Chamber body. As a general thing it may be said that the reporting of the exchanges is very well done, although now and then a little slip occurs, such as that which happened a few days ago on the Chicago Board of Trade, when the inaccurate statement of certain figures affecting the grain market caused quite a panic for a few hours, and made a considerable difference in the bank balance of several members.

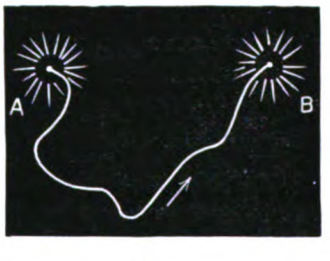
I notice a brisk discussion going on in your own columns, and those of your well-known contemporary, with regard to storage-battery cars, the use of overhead lines, and Mr. Sprague's position in relation to both methods of operating street railways. While Mr. Sprague is very enthusiastic with regard to the future of storage batteries, I do not think that anyone who has ever heard him speak on the subject would hesitate to say that at present he is an ardent advocate of and believer in the overhead line method of operation. In fact, all the work that his company is doing at the present time is by overhead wires, and the new contracts provide, it is said, for the same method. At the same time, the storage method is looked upon as the ideal to be aimed at; and, even if we cannot yet reach it, a great many efforts are being made, as we say, to "get there." The Julien cars are now running regularly in this city, creating a most favourable impression, and being very well patronised by the public. This week news comes from the Pacific Slope of the starting of a new road there, which is to be operated by storage batteries. The first car put upon the road has been built by the Electric Car Company of America with twin Reckenzaun motors of four horse-power each, developing up to eight horse-power, and with 80 cells from the Electrical Accumulator Company (E.P.S.). It is reported to be the intention of the Electrical Accumulator Company to start a factory on the Pacific Slope for the construction of its batteries, and colour is given to the report from the fact that Mr. Frederick Reckenzaun, from the Newark factory, is already out there. Meanwhile, in three or four cities ordinances have been passed to the effect that if electricity be resorted to, only storage batteries shall be used, and New Orleans is one of these places. Perhaps New Orleans furnishes as good an opportunity as any in this country for the adoption of the storage system. The city and the country around is as flat as a billiard table for miles and miles, and the main streets outside of the old French quarter are generally very straight, running long distances without a bend. The people interested in the New Orleans project are already connected with electrical pursuits, and are strong in various ways, so that something is likely to be accomplished in that quarter.

CORRESPONDENCE.

THE MUTUAL ACTION OF A PAIR OF RATIONAL CURRENT ELEMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Strictly speaking, there is no such thing, from the Maxwellian point of view, as mutual action between current elements. Suppose, however, we have the well-known Ampèrian field of magnetic force usually ascribed to a current element at one place, and a similar one centred at another place, it is clear that the forces concerned are quite definite, according to Maxwell's theory. The electric current of such an arrangement is closed. It is related to the nominal current, viz., in the element, in the same way as the induction of an elementary magnet is related to its magnetic moment, as regards the space-distribution. We may term the arrangement a rational current element. If we take any number of equal rational current elements and put them in line, with opposite poles in contact, only the terminal poles are left free, so that the current consists of a straight or curved line or tube of current, joining two points, A and B, with



external continuity produced by means of an equal current diverging from the positive pole B in all directions uniformly, and converging to the negative pole A in a similar manner. Of course the tubes of current from B join on to those at A, and are curved; but it would only confuse matters to super-impose the two systems of polar current, which are much better kept separate. The rational current element itself is to be regarded as an infinitely small volume with a uniform current distributed in it, *and* of the complementary currents from and to the poles. The moment is current-density multiplied by volume, ignoring the complementary currents altogether for the moment. What the actual current in the element may be does not matter much. It depends on the shape of the element. Thus, if spherical, the nominal strength of current, reckoned by its moment, is half as great again as the real, owing to the back action of the polar current. We need only consider the moment, which is fully representative of the external magnetic field, which, it should be remembered, is that due to the moment, according to Ampère's rule. To further illustrate, take the case of a charge, q, moving at speed u, small compared with that of light,* through a dielectric. The moment is qu; the magnetic force is qu/r^2 at distance r in the equatorial plane,

* See my letter in *The Electrician*, November 23, 1888, p. 84.

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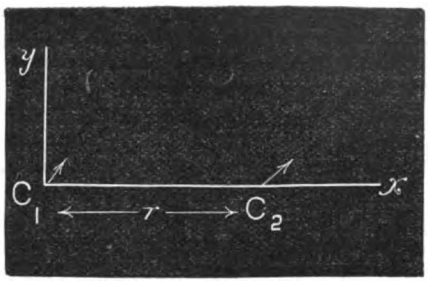
and elsewhere proportional to the cosine of the latitude. The actual state of things in the element may require very complex calculations to discover, but is of little importance.

The mutual action of two German or irrational current elements is indeterminate, and so we get a large number of so-called theories of electrodynamics. But the mutual action of a pair of rational current elements is a legitimate subject of inquiry, is determinate, and does not involve any action at a distance. The quantity from which, by dynamical methods, we derive the forces (mechanical) on the elements is the mutual magnetic energy (leaving out of consideration the electrostatic force, if any), that part of the magnetic energy due to both rational current elements. If I have correctly calculated it, the mutual energy M of elements whose distance apart is r, in the medium of inductivity μ, is expressed by

$$M = \frac{\mu}{2r}\left(2u_1v_1 + u_2v_2 + u_3v_3\right)$$

where u_1,u_2,u_3 are the components of C_1, the moment of the first element, and v_1,v_2,v_3 those of the second, C_2, on the understanding that the axis of x is the line joining the elements, whilst the y and z axes are, as usual, perpendicular to it and to each other. In another form



$$M = \mu\left(\frac{\cos\epsilon}{r} + \frac{1}{2}\frac{d^2r}{ds_1ds_2}\right)C_1C_2,$$

where ϵ is the inclination of the elements C_1 and C_2 parallel to s_1 and s_2.

If we substitute for r, in the differential coefficient, an arbitrary function R, we obtain the most general formula which will lead to Neumann's result for closed circuits. It is this R that is, by German methods, indeterminate. Rationalise the elements and we fix it to be r. Clausius took $R = 0$, I believe. It does not matter at all, so far as closed circuits are concerned, what formula we use, provided Neumann's result is complied with; but it is interesting to observe that the problem as stated by me has no uncertainty about it (except any possible working errors) and makes M definite, whilst it is not a mere mathematical abstraction (*i.e.*, the problem), but representative of (under certain circumstances) a reality. It is for these reasons that I mention the matter. For, as a matter of fact, I believe the whole method is fundamentally wrong, and of little practical service in the investigation of electro-magnetism from the physical side, *i.e.*, with propagation in time through a medium. What does it matter about the current elements? They are *not in it*. Still, such formulæ are sometimes of service, as, for instance, in the calculation of inductances.

It has been stated, on no less authority than that of the great Maxwell, that Ampère's law of force between a pair of current elements is the cardinal formula of electrodynamics. If so, should we not be always using it? Do we *ever* use it? Did Maxwell, in his treatise? Surely there is some mistake. I do not in the least mean to rob Ampère of the credit of being the father of electrodynamics; I would only transfer the name of cardinal formula to another due to him, expressing the mechanical force on an element of a conductor supporting current in any magnetic field; the vector product of current and induction. There is something real about it; it is not like his force between a pair of unclosed elements; it is fundamental; and, as everybody knows, it is in continual use, either actually or virtually (through electromotive force) both by theoretical and practical men.—Yours, &c.,

November 25, 1888. OLIVER HEAVISIDE.

ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Before replying fully to Mr. T. Parker's gratuitous criticisms on my work I desire it to be known that I have no grudge against this gentleman, and that I wish him and the company he is connected with every success in the difficult task they have undertaken in connection with electric traction. I have never had the pleasure of meeting Mr. Parker, and I feel sure that he would not have made the attack contained in your last issue had he studied the subject carefully, and had he considered the motives which led me to adopt certain principles. And I write this letter in the hope of dispelling erroneous notions among those of your readers who have not had opportunities of following up the various modes of arriving at the same ends which have from time to time been suggested by different workers.

The reasons why I have adopted a particular form of battery plate have been so fully and clearly stated in your issue of December 14th that I need not refer to them here; but, with regard to Mr. Parker's statement about Dr. Frankland's plate, I wish to say that I have been experimenting quite two years prior to applying for a patent on this method of constructing electrodes. Dr. Frankland applied for a similar patent nearly three months after me. I am satisfied, however, that Dr. Frankland had not the slightest idea of infringing. It appeared from some correspondence in the *Electrical Review* some time last year, that Mr. Epstein, in Germany, has also been working in a similar direction, and I am not at all surprised to hear of others who started in the same groove. If I have arrived at advantageous and definite commercial results before anyone else it was due to my own efforts, and to the assistance of those immediately connected with my business, and I disclaim all knowledge from any extraneous source. Whilst the broad idea of casting plates in the manner described required no great inventive faculties, the details gone through before we arrived at maximum useful effects with my traction cells were attended with an immense amount of trouble and expense. This truth Mr. Parker will be the first to admit and appreciate.

When giving his opinion about the employment of two motors in one car, Mr. Parker says, "In watching numerous experiments, we have found this has a great tendency for the cars to leave the rails." I do not see how one, two or more *motors* can influence the harmony between wheel flanges and rails. Several of the most experienced American firms have lately adopted my plan of using two motors on electric cars, for obvious reasons; four driving wheels must give better results than two, especially on grades. Much could be written about this branch of the subject, but I do not wish to encroach too far upon your valuable space, and many engineers are aware of the advantages of multiple driving wheels.

Referring to Mr. Parker's statement on the relative efficiency of two small motors against one of double the weight and power, I would suggest an experiment which will convince him that there is not much difference, and the advantages of double motors are numerous. Motors for self-propelled cars, if intended to work underneath the floor, have to be made of limited dimensions—that is to say, they must not have much depth, 10in. to 14in. at the most—although they may be of considerable length parallel to the axis of the armature. If we take, for instance, the iron carcase of a 16 horse-power tramcar motor, and cut the same in two halves, and if these halves are wound with the same section of wire and the same number of turns which were intended for the whole, there will be little difference in efficiency. The torque must be practically the same, and I limit this assertion to the above example of making two motors out of the iron and copper of one double the length and of equal cross-section. Continuing the sentence my critic says, "And they have double the liability to derangement" Now, if there is any "liability to derangement," then two motors are safer than one, because the probability is that both do not get deranged at the same moment, and one machine can drag the car home with a little extra exertion, provided that it is built with that margin which an experienced man will allow in designs of tramcar motors.

Mr. Parker thinks that "the mechanical mode of driving in

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this (my) car will not commend itself to mechanical engineers." I am accustomed to such remarks; many others who have not been sufficiently educated in this subject have ridiculed it. My experience in mechanical engineering extends over twenty-four years. The last eight years of this period I have devoted to electrical engineering, especially electric traction. It is more than four years now since I employed worm-gearing of a suitable shape for the purpose under consideration, and I took it up as a last resource after trying other kinds of gearing. I notice that several engineers have recently obtained good results with chains of a novel construction, and with spur-gearing of excellent design, but I am so satisfied with the working of worm-gear that I would not abandon it until something very much better can be provided.

The *commercial* success of electric traction does not depend upon a few per cent. more or less of efficiency in one particular part of the propelling apparatus, nor does it mainly depend upon the amount of coal burnt per car mile, but upon the total cost of traction inclusive of repairs and renewals. In addition to questions of economy the commercial success depends in a large measure upon points of convenience and safety, absence of noise and vibration, compactness, non-liability to break-downs, simplicity of management, and the like. I have not yet seen any mechanical gear entirely suitable for tramcars which has given 10 per cent. more efficiency than my gearing, and I venture to say that after several years' continuous use the total cost of traction with worm-gear, all other things being equal, will be found the cheapest.

Mr. Parker is most anxious to belittle every one of my efforts, and he says in conclusion, "The method of charging the field connections, so as to be able to run with a varying field in the motor, seems an ingenious contrivance for emptying the batteries, without obtaining the energy in the form of work upon the car." One of the nicest problems in connection with storage battery cars is the starting, the frequent necessity of overcoming the inertia of a heavy mass. In order to do this effectually the motors must be able to exert a great initial pull. This can only be obtained by the statical effect of a powerful field-magnet excited by a great number of ampere-turns. In order to keep the starting current within safe limits the turns of wire must be numerous, involving a considerable resistance. As soon as the motor has acquired a certain speed, and with it a counter E.M.F., this extra resistance is no longer wanted. Therefore, I divide the field coils of my series-wound motors into several equal parts and join all their ends in series when starting, *i.e.*, when I want the greatest effort with a reasonable current. Under these circumstances the apparatus gives the highest efficiency as an electro-magnet, intended to produce its maximum statical effect upon the armature. When I want it to work efficiently as a motor, with a maximum dynamic effect, then I join the ends of the said coils (automatically by the movement of a handle) so as to obtain one-quarter the resistance, which gives the usual car-speed with the most economical current without saturating the iron cores. If I want more power for mounting a steep grade at good speed I join the armatures in parallel, then the current is greater and the iron saturated; but I have still practically the same efficiency. Other combinations can be effected, but I need not enumerate them. In *all* cases all the wire is active, and the sectional area of the conductors adjusts itself to the current density. Of course the windings must be such that the efficiency is high under all circumstances; the important thing is to maintain certain relations between the conditions of electric supply and the speed and turning moment of the motor, and these conditions are obtained without any serious compromise. The cells in my cars are always all in series. I have tried other methods of varying the power by coupling cells in groups, by inserting artificial resistances between the cells and motors, and by using a variable speed gear; but none of these satisfied me as well as the above method, for reasons which I will not state here, because it is not in my right to ridicule the schemes of my rivals. Moreover, I am always open to conviction, always ready to learn, and I would rejoice to see other men successfully working in a different direction. I think it bad taste to run down in newspapers the work of competitors. We get very little encouragement from the public at large, the prejudices to be overcome are very great, and there is no need of the same being augmented by those most interested in the development of electric tramways.

I should like to see competitive public trials with electric cars made for the purpose of determining the merits of each kind or system, and the editors of our excellent engineering and electrical journals to be judges. Such a competition would save capitalists from plunging into immature ventures, it would draw public attention to a new and important industry, and it would speedily weed out sickly schemes unfit for existence, or hasten the cure of those not constitutionally weak, but merely suffering through disorders brought about by want of experience.—Yours, &c.,

A. Reckenzaun.

London, December 22, 1888.

THE BERNERS-STREET MISHAP.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I was very much surprised to see a statement in an editorial note in your last issue that the burning of a telephone bell in Berners-street is attributed to the end of a broken telephone wire having fallen across a line belonging to the Exchange Telegraph Company, and the sparks which flew across the room, and the shock felt by the lineman, were caused by the Exchange Telegraph Company's current, and had nothing to do with the electric-light wire.

I have referred to the original letter in the *Standard* which first drew attention to this circumstance, and find that the great noise which threw off the gong of the telephone occurred in the night of Friday last, and the smell of burning flame bursting from the wire, sparks flying across the room, &c., occurred at about 11 a.m. on Saturday.

We have but one wire in that locality, and the last message of the day was transmitted at 3 p.m. on Friday, and on Saturday nothing was transmitted between the hours of 8 a.m. and 12:30 p.m., and no contact with another source of electricity occurred.

I think, Sir, that you should have ascertained the grounds, if any, for such a serious statement before publishing it as a fact. The current we employ is incapable of producing the effects described, which are no doubt due to the electric-light cable, which is so imperfectly secured that it has dropped upon our wire three times, without, however, doing any injury to our apparatus, owing to the protecting covering upon our wires.—Yours, &c.,

F. Higgins.

[In the paragraph of which our correspondent complains we stated in perfectly unmistakable terms that the destruction of the telephone was due to a cross with an electric-light wire. But since the telephone wire was melted at the point where the contact occurred, and the end fell over another wire, it is clear that the "sparks," which were seen when the lineman opened the instrument did not come from the electric-light circuit. We further hinted our belief that, whatever may have really happened at this moment, the description in the *Standard* was grossly exaggerated. We understand that the lineman denies that the shock which he experienced was "sufficient to make him let go the pliers," and the "sparks flying across the room" was also a palpable exaggeration. So that whether it was or was not an Exchange Telegraph Company's wire on which the telephone wire had fallen seemed to be a point of no importance whatever. However, if our information was incorrect, we regret to have alluded to the Exchange Company in connection with the affair.—Ed. *E.*]

MR. ATKINSON'S BOOK ON "THE ELEMENTS OF ELECTRIC LIGHTING."

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am informed by the publisher of my recent work, "The Elements of Electric Lighting," that various English publishers propose to prohibit its sale in England, on the ground that it contains matter appropriated from English electric works published by them.

As I have always had such contempt for plagiarism that I seldom even quote from another writer, preferring to use my

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own phraseology when adopting the ideas of others, I was much surprised to learn that such a charge had been made, and must infer that it is not possible that any of these gentlemen can have carefully read or examined my book. A charge of theft, literary or otherwise, "cannot be sustained till the property is found in possession of the thief and identified," and the burden of proof rests upon those bringing the charge. My work is before the public, and no one can show a single line which I have appropriated from any other writer except in my summary of installation rules, pages 254 and 255, which I do not claim as my own. I found these rules given in common by different writers, and modified them to suit my purpose.

In my chapter on the storage battery I adopted the theory of Gladstone and Tribe, using my own phraseology, and giving them full credit, both in my introduction and on page 218.

As stated in my introduction, I consulted the works of several different writers mentioned by name, and embodied in my own language, modified by my own ideas, such matter as I found adapted to my use. This I understand to be the privilege of every writer. No scientific writer can claim to be wholly original—his writings are necessarily based on information derived from others, whose ideas have become incorporated into his own body of thought. And as the object of a book like mine is to give the latest and most reliable information obtainable on the subject, and not merely one's own peculiar views, I not only consulted other writers, but made a thorough practical examination of the various kinds of apparatus described and the principles of their operation; visiting factories and inspecting machines and apparatus in the various stages of construction; conversing and corresponding with inventors and manufacturers; examining patents, and by every possible means seeking full and accurate information on every point.

My illustrations were obtained from various sources; some from books, pamphlets, and periodicals, others from cuts lent me by patentees and manufacturers, and others from my own drawings; most of those from outside sources requiring modification to adapt them to my use. Some of these illustrations are the same as those found in English books, and yet even these are, in many instances, identical with those from cuts lent me by American manufacturers, while others are found in common in various electric works, so that I had no evidence that any of those copied from English works were from original drawings designed for any particular book; indeed, the authors themselves acknowledge that their illustrations were in part obtained from outside sources. Hence I have only followed the common practice of others by copying such illustrations as I found adapted to my use, for which, in my introduction, I have given full credit.

English electric books have had a large circulation in the United States, and common courtesy would seem to require that my book should have the same opportunity for circulation on its merits in England.—Yours, &c., PHILIP ATKINSON.

168, Randolph-street, Chicago,
Illinois, U.S.A., November 30, 1888.

BOOKS, &c., RECEIVED.

"The School of Mines Quarterly." Vol. X. No. 1. (New York.)

"Illustrated and descriptive Catalogue of the Thomson-Houston Electric Company." (Boston.)

"The American Journal of Science," Vol. XXXVI., December, 1888. (J. D. and E. S. Dana, New Haven, Conn.)

"The *Journal* of the Franklin Institute." Vol. CXXVI., No. 756. (Philadelphia).

"*Transactions* of the Institution of Civil Engineers of Ireland." Vol. XVIII. (Dublin)

"Professional Papers of the Corps of Royal Engineers." Edited by Major Francis J. Day, R.E. Vol. XIII. (Chatham).

"The *Proceedings* of the Royal Society." Vol. XLIV., No. 272. (London: Harrison and Sons).

German Nomenclature.—The Germans have built up a somewhat monumental name for multiple switchboard, they call it a "fernsprechvielfachklappenvschranke!"

PATENT RECORD.

APPLICATIONS FOR PATENTS.

16,249. A. P. LUNDEBERG. London. An improved "bar" or "bridge" electric light switch. November 9, 1888.

16,256. L. B. MILLER. London. Improvements in electric meters or apparatus for measuring electricity. November 9, 1888.

16,264. G. BINSWANGER. London. Improvements relating to incandescent lamp holders, applicable also to cut-outs, switches, and the like employed with electric currents. November 9, 1888.

16,289. S. BUNTING. Dublin. Improvements in apparatus for gas and electric meters. November 10, 1888.

16,298. T. PEASE. Liverpool. Improved tramcar, omnibus, or other wheeled vehicle, with method of carrying and applying stored electricity for the propulsion of such. November 10, 1888.

16,302. C. A. JOHANNES, H. SCHROEDER and H. E. R. SCHROEDER. London. An improved arrangement in construction of primary batteries, by which "abnormal" voltage per cell is obtained. November 10, 1888.

16,309. L. HUEBNER and R. BUSSE. London. Electric locking mechanism for safes and for other purposes. November 10, 1888.

16,339. C. LANGDON DAVIES. London. Improvements in the generation of rhythmic electric currents. November 10, 1888.

16,343. F. S. WILLOUGHBY and F. C. LYNDE. Manchester. Improvements in incandescent lamps. November 12, 1888.

16,438. H. WILSON. London. Electric register for taking speed of ships November 13, 1888.

16,471. J. S. RAWORTH. London. Improved means or apparatus for reversing and regulating the brushes of dynamo-electric machines, partly applicable to electric motors. November 13, 1888.

16,478. G. F. REDFERN. London. An improved device for use in establishing electrical communication (D. S. Boivin and R. A. Gouamier, France). November 13, 1888.

16,479. H. H. LAKE. London. Improvements in storage or secondary batteries (H. Walter, United States). November 13, 1888.

16,481. J. Y. JOHNSON. London. Improvements in the mounting of diaphragms of graphophones, telephones and the like (the Volta Graphophone Company, United States). November 13, 1888.

16,484. E. M. H. ANDREOLI. London. Improvements in ungumming and bleaching by electrolysis flax, hemp, cotton and similar exogenous plants. November 13, 1888.

16,570. H. PIEPER FILS. Berlin. Improvements in electric lamps. November 14, 1888.

16,603. E. K. IRWIN. London. An improved automatic electric signalling apparatus for railways. November 15, 1888.

16,623. LAURENCE, PARIS and SCOTT (Limited) and W. H. SCOTT. London. Improvements in electricity meters. November 15, 1888.

16,625. E. W. ANDERSON. London. Improvements in electric arc lamps November 15, 1888.

16,629. F. CRAMER. Germany. Improvements in galvanic batteries November 16, 1888.

16,653. O. FRONLY. London. Improvements in electro-motors. November 16, 1888.

16,654. C. M. DORMAN and R. A. SMITH. Manchester. Reflecting shades for electric lamps. November 16, 1888.

16,658. T. TAYLOR and W. TUNNICLIFF. Birmingham. Improvements in or connected with safety junctions for electric lighting. November 16, 1888.

16,681. F. J. PATTEN. London. Improvements in and relating to multiple telegraphy. November 16, 1888.

16,694. J. H. THOMSON. London. Improvements in electrical instruments for transmitting information. November 16, 1888.

16,728. N. G. THOMPSON. London. Improvements in dynamo electric machines. November 17, 1888.

16,740. J. A. TIMMIS. London. Improvements in the arrangement for working railway signals and points electrically. November 17, 1888.

16,809. H. J. HARRIS and J. GARFORD. London. Improvements in voltaic batteries. November 19, 1888.

16,813. G. C. FRICKER. London. Improvements in secondary generators or induction transformers. November 19, 1888.

16,829. R. THOMPSON. Liverpool. An improved portable lamp and dynamo combined. November 20, 1888.

15,851. W. T. GOOLDEN and S. EVERSHED. London. Improvements in apparatus for electro dynamically controlling motion. November 20, 1888.

16,852. W. T. GOOLDEN, L. B. ATKINSON and S. C. G. GOLD. London. Improvements in appliances designed for use in connection with variable electric currents, the said improvements being also applicable to alternate-current motors. November 20, 1888.

16,855. F. MORETON. London. A combined electric conductor and interrupter. November 20, 1888.

16,881. W. SPARROW. Harpenden. An improved method for utilising gas and electricity for illuminating names of railway stations, shop signs, facias, and trade signs generally. November 20, 1888.

16,900. C. GRIVOLAS, Jun. Birmingham. Improvements in electrical fusible cut-outs. November 21, 1888.

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16,928. R. R. HUTCHINSON. London. Improvements in brushes and contacts for dynamo electric generators, motors and other purposes. November 21, 1888.

16,939. G. BINSWANGER and H. J. COATES. London. Improvements in the construction of electric bells. November 21, 1888.

16,946. J. Y. JOHNSON. London. Improvements in fittings and switches for incandescent electric lamps (T. Mace, United States). November 21, 1888.

16,947. L. PARIS AND SCOTT (LIMITED) and W. H. SCOTT. London. Improvements in connection with continuous electric current transformers for automatically regulating the current in the working circuit. November 21, 1888.

16,954. F. A. OETZMANN. London. Improvements in electro-plated goods and in the process of manufacturing the same. November 21, 1888.

16,959. C. F. HILKIER. London. Improvements in electric contact apparatus to be operated automatically by heat or by hand pressure. November 21, 1888.

17,002. T. COAD. London. An improved fluid for primary batteries. November 22, 1888.

17,013. C. WATSON. London. Improvements in electric meters or apparatus for measuring electricity. November 22, 1888.

COMPLETE SPECIFICATIONS ACCEPTED.

November 24, 1888.

12,676. W. T. GOOLDEN and L. B. ATKINSON. London. Improvements in dymano electric generators and motors. September 19, 1887.

17,231. H. EDMUNDS. London. Improvements in means for the distribution of electricity. December 14, 1887.

718. E. GIUTTON. London. Improvements in self-acting electric batteries or generators, in which the liquids are automatically renewed (M. Sappey, France). January 17, 1888.

981. C. SPRATT. London. Improvements in electric "call" signal apparatus. January 21, 1888.

9.4. W. F. BURLEIGH. London. Improvements in controlling railway signal levers by the application of electricity. January 23, 1888.

13,598. R. R. HUTCHINSON. London. Improvements in electric motors. September 20, 1888.

14,980. R. R. HUTCHINSON. London. Improved method of and apparatus for operating capstans, windlasses, hoists and the like by means of electricity. October 18, 1888.

14,985. R. R. HUTCHINSON. London. Improved method of and apparatus for utilising a current of electricity for operating pile driving machinery and rendering the action of same automatic. October 18, 1888.

14,981. R. R. HUTCHINSON. London. Improved method of and apparatus for actuating printing machinery by meaus of an electric current, and instantaneously checking or arresting the motion thereof when required. November 18, 1888.

14,986. R. R. HUTCHINSON. London. Improved method of and apparatus for applying electricity as a motive power to cranes, sheer legs and the like. October 18, 1888.

14,988. R. R. HUTCHINSON. London. Improvements in "mashers" and "mixers," as employed in brewing and other processes, and method of and apparatus for applying electricity as a motive power for same. October 18, 1888.

14,989. R. R. HUTCHINSON. London. Improvements in steering apparatus for ships and method of and apparatus for utilising electricity as a motive power for same. October 18, 1888.

COMPANIES' MEETINGS.

Metropolitan Electric Supply Company (Limited).

An extraordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Friday, December 21st, 1888, under the presidency of Sir John Pender, K.C.M.G.

The CHAIRMAN, in opening the proceedings, said: Gentlemen, the Secretary will read the notice convening this meeting.

The SECRETARY (Mr. E. Cunliffe Owen) having read the notice,

The CHAIRMAN said: Gentlemen, we have called you together to-day for two purposes—first, to inform you as to the progress the Company has made since August last and its present position and prospects; and, secondly, to put before you a resolution approving an agreement made by the Board, under the power of the Articles of Association, to vary the original agreement entered into between this Company and the Whitehall Company for the purchase of the property and the undertaking of the Whitehall Company. And first, with respect to the work done. You are aware that the Company took over from the Whitehall Company the important works and installation which the latter had established at Whitehall Avenue. That station, which has about 10,000-light capacity, was opened on the 5th October last, and the Directors had hoped that the full capacity of lighting would be taken up by customers in seven or eight months. Instead of this, the full capacity of the station is taken up already. In about two months orders were booked for nearly 9,000 lamps, and the mains for connecting them are being laid as fast as possible. The Avenue Theatre, the Hotel Victoria in Northumberland Avenue, and other places have been lighted for some time, and the managers have written expressing their satisfaction with the supply, and among the more recent contracts secured to be worked from the Whitehall station are the Grand Hotel, Messrs. Hampton's large furniture warehouses in Pall Mall, St. Martin's Church, and other places. The Company's mains are being laid underground throughout the whole of the Charing-cross district, and have already been laid across Northumberland-avenue, West Strand, and Trafalgar-square, without causing any appreciable interruption to the traffic. Mr. Gordon informs me that the guaranteed revenue from the contracts made and to be carried on from the Whitehall works is £13,500 a year, and that other contracts, expected to be completed in a few days, will be another £1,000 making altogether £14,500. The working expenses, including rent, salaries, wages, and 10 per cent. for depreciation, are estimated at £6,000, leaving a profit of £8,500 a year on these installations, which, I think, is fairly satisfactory, seeing that the capital represented by these works is not much over £40,000. As to the Sardinia-street works, the buildings in Sardinia-street are in hand, and a large body of men are employed on them. We have put up a map here in which you see the Sardinia-street station. I may say without any hesitation or fear of contradiction that that station will be one of the most important in London. It embraces the important residential property about Bloomsbury, the shops, hotels, and large restaurants in Holborn, the important newspaper, publishing and printing establishments about Fleet-street, and the banks, shops, and numerous buildings in the East Strand district. That station will, I think, have altogether 50,000 lights, and so far as we can see now and judge from the inquiries that are made, it will not be a long time after the installation is completed before that will be fully occupied; and if the results upon the 50,000 lights are at all in proportion to what we now see from the practical working of the Whitehall works, I think we may congratulate ourselves on being in a position to make very handsome dividends. I may mention that the machinery for this station has been ordered from the Westinghouse Company, and the bulk of it will be delivered in a very short time. The object of ordering this machinery from the Westinghouse Company is this—that they have put down in America 116 installations, all of which have been successful, and the principle we have gone upon—what has been the policy of this Company, because we have not been idle during the last six months—has been to take the very best thing in existence, and to utilise it for our purposes. This American system is considered almost perfect, as far as it has gone. We are inviting tenders from English contractors for another installation, and so we shall work one against the other, and we shall have the full advantage of what I may call contractors' competition. I think the result of that will be to give us the best thing of the kind up to the present moment. I do not mean to say that in electricity, as in other things, there is not very great progress. You will see that that is the case when I tell you that it is scarcely ten years ago since electric lighting was a laboratory experiment, whereas it is now almost becoming universal. I may go further and say this: It is not more than twenty-five years since submarine telegraphy was first introduced, and there is now £40,000,000 sterling in the bottom of the sea, the major portion of it paying a fair dividend. That shows that we do not know to what extent electricity can be carried; but, so far as we have gone, it seems that the electric light is to be the light of the future. I have no hesitation in saying, if you look at the prospectus we put before you—it was based on a good deal of experience—you will find that what we said in regard to the American installations ought to be thoroughly borne out also in regard to English installations. The Company also took over from the Whitehall Company the extensive and valuable property for electric lighting purposes, the Waterloo Bridge Wharf, which is admirably adapted for supplying the whole of the Strand district, and which can take the machinery required for working 150,000 lamps. That, I think, will be perhaps the largest installation in our system. I want you to understand that we have not gone, in the slightest degree, upon a speculative or experimental policy. We are laying down installations which we know will be successful, so far as the mechanical part of them is concerned, and we believe that the light will be fully taken up by the public; and, therefore, I think we are not over sanguine in looking forward to very successful results. That installation is one which, I hope, will, before another year is out, be in active operation. We know that there are very formidable competitors in the market at the present moment. I greatly admire the enterprise of the Grosvenor Gallery combination, the gentlemen connected with which are of the highest eminence. They have great practical scientific knowledge among them, but they are trying the biggest experiment ever tried in electric lighting, so I am informed by scientific men. I hope their experiments may be successful. I like to see these great efforts of science successful, and I believe if this experiment is successful it will be a very remarkable step in electrical progress. We have been more cautious, probably more prudent. We are not putting all our eggs in one basket. We are so putting our different installations that we can work them collectively or separately; consequently we are not likely to break down as a whole. You can see the object of that, and we have acted upon the advice of our eminent scientific advisers. Therefore, every installation of ours will stand alone, but every installation will stand shoulder to shoulder with its neighbouring installation if so required. Since August last (I have said that we have not been idle) the Directors have secured several other sites for works. One is Greenmore Wharf, a large wharf adjoining Southwark Bridge, which is suited for lighting the City of London proper. We have also obtained a site in South-mews, Manchester-square, for the Marylebone district. Negotiations are proceeding for other sites. The specifications for the machinery for the Greenmore Wharf have been sent out, and tenders are expected in a week or two from various responsible English firms. Specifications for the other sites will go out immediately. With regard to the Strand district, the Company has secured a monopoly of the lighting of the new Salisbury Estate, consisting of Salisbury and Cecil streets, for the ground of which alone a sum of £200,000 has recently been paid. That will probably be one of the most remarkable improvements in London. I cannot say much more with regard to our prospects. In the summer it was said they were encouraging, and I think if I went over article by article in the prospectus put before you, I could justify every item in it. The second portion of our business to-day I hope will also be satis-

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factory, because it is very much for the benefit of the Company's interests, though probably not so much to the satisfaction of others, who have been working for the last two or three years, and who consider themselves very badly paid indeed for their work and property. I may say at once that the short result of what we ask you to confirm to-day is to reduce by just one-half the purchase money payable by the Company for the property and rights which they agreed to take over from the Whitehall Company. The price is reduced from £79,000, the sum named in the prospectus as having been fixed by the vendors, the Whitehall Company, to the very modest sum of £40,000. This, you will see, is practically reducing the purchase money by one-half, and I am sure every shareholder in this Company will be glad that this reduction is to be made. The vendors are willing to make the reduction, though they are by no means satisfied with the decision that Sir Frederick Bramwell and Sir Whittaker Ellis have arrived at with respect to the value of the property. It was, of course, to be expected that the vendors would take a more favourable view of their undertaking than what I may call cold-blooded but very experienced gentlemen who sat down to value what was placed before them. The vendors made their arrangements with the Company at a time when there were really no shareholders but themselves and their friends in the Company. No man could then, nor can even now, estimate absolutely what is the value of the undertaking we have purchased. I have told you to-day of our prospects. Probably a year or two hence our stock may be worth twice or thrice what it is to-day, so you see how difficult it is to value a thing which has not been fully realised. Therefore, in this valuation, though it is not so stated, probably nothing has been taken into consideration as to the prospective value of the Company. I do not know what was in the minds of the valuers, and they have, perhaps, wisely given no reason for their decision, but from the course of inquiries which they have made very carefully in respect to the properties actually transferred I have no doubt they have omitted from their calculations these elements of future value which the vendors not unreasonably considered so important. I may add that the vendors would be perfectly willing to take back their properties if the Company did not desire to go on with the purchase; but I believe I am right in saying that every member of the Board is convinced that the property is well worth, and more than worth, the sum we have now decided to pay for it. One other matter ought also to be mentioned, that is with respect to the provisional order which the Board of Trade had granted before the prospectus was issued. This provisional order gave to the Company valuable rights over the parish of St. James's, Westminster, and St. Martin's-in-the-Fields; and when the Duke of Buckingham, as Chairman of Committees of the House of Lords, refused to suspend the standing order which prevented the second reading of the Government Bill to confirm that provisional order, the Board of Trade promised to use their good offices to support a private Bill to enable the Company to secure the confirmation of that provisional order in the next session. The loss of this provisional order, in the sense I have mentioned, occurred between the time when the agreement was made and the prospectus prepared and the date of its actual issue, and I think the valuers must have made a large reduction from the original price on account of the unfortunate slip, which was occasioned by no fault of the promoters but through the delays in Parliament. When the prospectus was issued, and the shares were so readily and so largely subscribed, and so many new shareholders came into the Company, the Directors sat down to consider the position and the course they should take in consequence of the changes which had occurred, and they came to the conclusion that there should be, in the interests of all parties concerned, an independent valuation of the property which the Company was to purchase. Several of the Directors were themselves interested in the properties which had been acquired and were to be sold by the Whitehall Company, and this made it the more necessary that such a valuation should be taken. The South Metropolitan Company was threatened with opposition by the Whitehall Company, and it was really this that brought about the combination of the two parties, one represented by Sir George Elliot and his friends, who had taken a deep interest in this question, and the other by Mr. Balfour and his friends, who had invested largely in the Whitehall Court enterprise, and who had founded the Whitehall Electric Company. The agreement referred to in the circular, which has been sent to you, dated 12th December, 1888, will now be read to you by the solicitor. It has been made especially under power of the Articles of Association, which contain an important clause authorising this being done. The solicitor will now read the agreement.

The SOLICITOR (Mr. Burt): Mr. Chairman and gentlemen, the clause in the Articles of Association is as follows:—

"The Board may, with or without variation, carry into effect on behalf "of the Company, the agreement between the Whitehall Electric Supply "Company (Limited) of the one part, and this Company of the other part, "by which the Whitehall Company, for the consideration therein men-"tioned, agrees to convey and assign to the Company all the property and "rights as in the said agreement more particularly mentioned."

That agreement is annexed to these Articles of Association, and I suppose is in the hands of the shareholders; and the agreement which you are called upon to confirm to-day is as follows. [Mr. Burt then read the agreement.] That is signed, and there is also an endorsement upon it signed by Mr. Verity. [The endorsement was read.]

The CHAIRMAN: Gentlemen, I will put this resolution, and after I have put it, if any gentleman has any remarks to make, or questions to ask, I shall be very glad to answer him to the best of my ability. The resolution is as follows:—

"*Resolved that the agreement dated the 12th December, 1888, made between the Board of Directors of the Company of the first part, and Sir John Pender, Sir George Elliot, Joseph Charles Parkinson, Esq., and the Whitehall Electric Supply Company (Limited) of the second part, for varying the agreement dated the 17th July, 1888, referred to in the Articles of Association (Clause 6), and made between the South Metropolitan Electric Supply Company of the one part and the Whitehall Electric Supply Company (Limited) of the other part, by which the said Whitehall Company, for the consideration therein mentioned, agreed to convey and assign to the South Metropolitan Company its undertaking, property, and rights as therein mentioned, be and is hereby confirmed.*"

ALDERMAN SIR R. N. FOWLER, M.P.: I second that.

Mr. DIBLEY: I am sure we must agree with the resolution placed before us by the Board, amending to a large extent the contract made between the Whitehall Company and this Company; and I think before you put the resolution I may express what I believe is the feeling of everyone present when I congratulate the Board on the arrangement they have effected.

The CHAIRMAN: Those in favour of the resolution hold up one hand. To the contrary. Carried unanimously.

Now, gentlemen, we have given you to-day a straightforward statement, and I wish to give you also a little further information, so that on leaving this room you will understand that the gentlemen connected with this enterprise have made up their minds to make it go ahead. We believe the time has come, and that there is a great deal of good useful paying work to be done with electric lighting. This is the further information I will give you. The Company has given notice of a Bill in Parliament to obtain Parliamentary powers to carry on the works for St. James's, Westminster, St. Martin's-in-the-Fields, and Waterloo Bridge, which will include the ground covered by the provisional order which was obtained last summer, but which was not confirmed by Parliament, although the Board of Trade did all in their power to get the Bill passed. Notices have also been given for provisional orders in four districts—Mid-London, North London, South London and West London. It may be that we shall not proceed with all these, but we thought it wise to give the notices, without which we could not proceed. In view of all the works executed and in hand, and what is proposed to be done in the future, the Directors think the prospects of the Company, as put before you to-day, are very encouraging indeed. There is another point. Some people have said to me, "But there are more electric lighting companies in existence than can possibly be required." But the population of this mighty city is five millions of people, and if the electric light is successful (and I believe it must become the light of the future), we shall require to spend thirty-four to thirty-five millions sterling before we can do the work required. Therefore, when I find respectable people—people of high position having money to spend—coming forward to take part in this work I hail them with great satisfaction. There is plenty of good-paying work for us all. As I said before, electricity is yet in its infancy, and the more that science can be brought to bear upon it the more we shall have of this light. The light is doing a great sanitary work, and with its use the air remains pure, and there is less heat. I have not a word to say against gas. I believe that gas, being the essence of heat from coal, has a great deal of work before it, but in another field than that of lighting. Those interested in gas must look to apply it to other purposes. The light of the future is to be the electric light. That finishes the business of the day, gentlemen.

Mr. DIBLEY: I am sure before we part we should all pass a vote of thanks to the Chairman.

A SHAREHOLDER: And the Board?

A SHAREHOLDER: I second that.

Mr. DIBLEY put the resolution, and it was carried unanimously.

The CHAIRMAN: Gentlemen, I thank you on behalf of my colleagues and myself, but I shall receive your approbation with much greater satisfaction after we have paid you a dividend.

The proceedings then terminated.

The London Electric Supply Corporation.

The second ordinary general meeting of this Company was held on Friday at Winchester House, Old Broad-street, E.C., the Earl of Crawford in the chair.

Major CHARLES B. WALLER (the Manager and Secretary) read the following notice convening the meeting, and the report of the Directors was taken as read:—

Notice is given that the second ordinary general meeting of the London Electric Supply Corporation (Limited) will be held on 21st December, and that at such meeting a resolution will be proposed to increase the capital of the Company by the creation of 50,000 new shares of £5 each, to be called Preference shares (with power for the Company to create further new shares to rank in all respects *pari passu* with the said Preference shares, to all of which shares shall be attached the following rights and privileges, viz.:—

"*1. The holders of such Preference shares shall be entitled, out of the profits of each year, to a preferential dividend on the capital for the time being paid up on such shares respectively, at such rate as the Board before the issue thereof shall fix, but without a right to any further participation in profits.*

"*2. That in the event of the Company being wound up, the holders of the said Preference shares shall be entitled to have the surplus assets of the Company applied in the first instance in repaying to them the amount paid up on shares held by them respectively, the residue of such surplus assets being divided amongst the holders of the other shares of the Company (hereinafter called Ordinary shares).*

"*3. Any holder of the Preference shares shall be entitled, at any time within five years from the 31st December, 1888, to relinquish the preferential rights of such of the said Preference shares as are held by him and are paid up in full, and thereupon each of such shares shall thereafter become and be Ordinary shares of the Company.*"

Dated the 11th day of December, 1888.

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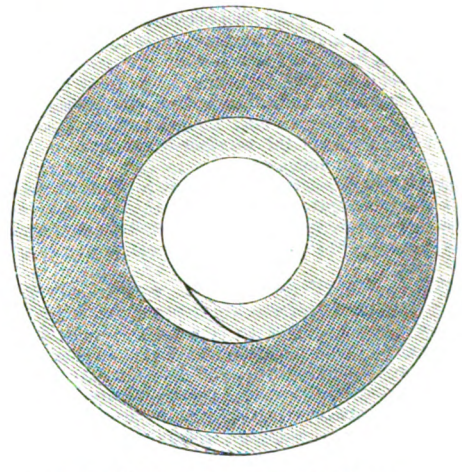
The CHAIRMAN said: I think, gentlemen, it would be desirable that I should make a short statement on the report, embodying certain details which are not therein contained. In order to do that I purpose to say a few words, to begin with, on the station which is at present at work belonging to you, which is the station known as the Grosvenor. The Corporation has now been at work since the early part of October, in 1887. At that period they took over the works then existing behind the Grosvenor Gallery, and a set of works, with overhead mains and plant, which had been put down there, and which had lit at that time something like 11,000 lamps. The capability of the Grosvenor Station was originally supposed to be 10,000 lamps running simultaneously. Some time previously to the purchase of the business by the present Corporation the Directors of that Company had spent a considerable sum of money in order to place the dynamos and their engines in a much more advantageous position, in so far as the number of lights they were able to supply simultaneously. They contracted with their engineer to supply dynamos which would be sufficient to give current to 20,000 lights at the same time. It was found when these machines were put into position that the nominal efficiency of 20,000 could be exceeded to the extent of one-third—that is, that the nominal efficiency of two machines, working simultaneously, being 20,000, it would be safe to light 30,000 lamps; therefore, your company got possession of two dynamos capable of giving 30,000 lights. In addition to that there is a system of engines, which is very complete; but, unfortunately, for the present they are not quite sufficiently powerful for the large amount of work which is demanded from those engines. That quantity of power in excess cannot be got from that point, simply and solely because there is not cubic capacity left in the building in which we are working to put down additional machinery. Again, outside your engine room your Company purchased a very large and widely extended system of overhead mains—that is to say, cables, or means of conveying the current from the generating station to the house of the consumer. A good deal has been said, gentlemen, on the question of overhead mains with regard to the safety to the public, which has been called in question. The first danger which has been called in question may be said to be that of a cable breaking, falling down and hitting some person on the head, and killing him or maiming him; the second is, that a man, by touching a main, may get a bad shock, or even be killed. We had confidence that our mains were put up in a proper manner from the commencement; we used the greatest care and the best material we could, and after we had been at work for three years and six months, practically speaking—I should say I am speaking for the old company—but it was rather more than a year after the present Corporation had been at work, the Board of Trade sent to us a letter, saying that they had heard that we were using overhead wires, and they wished to know the factors of safety employed by us in putting these wires up, and what precautions we had taken with regard to giving shocks to persons, and so on. We then said to the Board of Trade: "We shall be very happy to take down the line of wire which has been longest in course of work, place it before you, and allow you to test it in any way you please." The wire was taken down which had been up three years and seven months, it was placed in the yard we use for our stores, the current was put through, and the tension was exactly the same as when it was on the roof, and then one end of that cable was dropped down to earth, technically speaking. Practically it means, supposing the two wires were overhead and got broken and hung to earth, any person touching the wire would not get a shock. We were able to show to the Board of Trade there was not the danger they anticipated. They then said: "Well, your experiment is most successful." The work which had been put up three years and a-half was as good as ever. In October, 1887, your Corporation had about 11,000 lights upon its books; I think I shall best show the shareholders the actual amount of work which has been done since that time by placing before them a series of curves representing the work done in each week. (The Chairman exhibited the drawings referred to and continued): With regard to the curve showing the effect of the foggy weather on the Grosvenor Station,* you will perceive that in the early portion of the day at 11:30 the amount of current—that is the number of lights that were lighted simultaneously—was greater than at any other period during the twenty-four hours of the day. Some little time ago, as you are all aware, it was decided to start another station, as it was found that the demand on the Grosvenor was becoming excessive; we therefore established an installation at Deptford. At the time we got our estimates we were in full confidence that at the present date we should have been supplying a current from that place; but owing to the excessively bad summer and the rainy weather, we found we lost nearly two months, and consequently have been thrown back in that manner. We considered ourselves perfectly justified in taking on customers to be supplied from Deptford. We have been disappointed in that matter, and the result is we have been compelled to take on customers at the Grosvenor until in point of fact we have now 34,000 lights contracted for, and we have been running up to 25,000 simultaneously. Now, it is really the case that it is not desirable to work the Grosvenor engines and boilers to that extent, consequently your Directors have been doing everything in their power, with the consent of consumers, to induce their customers not to use so much current as they were doing. In many cases the consumers have been behaving very considerately, and we have been able to bring the load down to some extent, but many of us would desire to have even more relief. I think I may now pass from the Grosvenor Station, and tell the gentlemen present what we are doing at Deptford. When the present company came into existence it purchased from the old company, or rather took over, a large piece of land of nearly five acres in extent a little to the east of the London Meat Market, next door to the Steam Navigation Company. That land had been lying vacant, and it was admirably adapted for our purposes, especially as it possessed a large river frontage. I hardly think it will be necessary for me to go very fully into this matter, because we have placed in your hands certain documents prepared for the local authorities. The best way that you can, perhaps, get at an idea of the magnitude and scale of these things will be to look at the photographs which I will hand round.* What we have at Deptford to put up to begin with will be a dynamo with its engine capable of giving 25,000 lights simultaneously, and we have every reason to hope that that 25,000-light dynamo will be able to do eventually 30,000 at least, and we shall have another dynamo, also the same size—25,000—which makes 50,000. These will be the first two instruments at work; one will be running, the other will be invariably kept at rest; therefore, at Deptford we shall not have to run everything in order to meet the demand. At Deptford we have a large amount of reserve power, which we consider to be essential to the proper carrying on of a business of this description. As soon as that 25,000-light dynamo is finished we shall have begun erecting the large dynamos, which will be driven by engines of 10,000 horse-power running direct on the dynamo, which will be capable of a simultaneous output of 100,000 lights. Two of those will be put up, and so far the Directors have already ordered the material. The utilisation of those dynamos—that is to say, the current which they produce—is passed up to London by means of copper mains, of which I have a sample here, of a novel construction, and which have done away with all the difficulties which have hitherto been found in electric lighting. The peculiarity of this is that there is one main inside the other (*see* Figure), so that one current passing along kills



Cross Section of Ferranti Conductor.

the effect of the induction of the other. Having got these cables we have to bring the current up so far as London. We knew very well at the time we started this business it would be impossible for us to get Parliamentary sanction for going under the streets at the time which we thought it desirable to commence work, owing to the ordinary formalities of Parliament, and therefore your Board made arrangements with the railway companies in order to obtain their co-operation, as theirs was practically private property, running through different parishes, and therefore not subject to their jurisdiction. Negotiations with the South-Eastern, the London, Brighton and South-Coast, the Chatham and Dover—the Herne Hill Branch—have resulted in our obtaining by means of these three companies way-leaves whereby we can bring the current all the way in an easy and most practical manner into the heart of London. We bring the current across the bridge into Cannon-street, Blackfriars and Charing Cross Stations. Rather before that the Directors entered into arrangements with one of the underground railways for the use of their tunnels. I am not able to say that we have the complete circuit of London at the present moment, because a certain portion is still under negotiation, although the principle is conceded and the agreement practically finished. The only question outstanding is how much per mile we have to pay; I think you may trust your Directors to fight for that being as little as possible. That brings us practically up to London, and our first thing is to carry the mains throughout the town, first by overhead mains, and subsequently, when we obtain provisional orders, by means of taking the streets up and putting mains down underground. In order to give the shareholders an idea of the amount of work which it is our desire to be able to carry through before very long, I brought up a copy of the map we have deposited with the Board of Trade, showing the area for which we have applied for provisional orders. We have asked for powers to deal with the streets in 24 different localities, under the jurisdiction of 24 different local authorities. So far as we have gone through the work, we have given the notice—previous to that we gave notice also for licenses. Well, by the Act of 1882 there were two methods of procedure—one by license, which requires the consent of the local authority and the Board of Trade giving permission for any work to be done; the other method being that of provisional orders, where the Board have power on good reason shown to dispense with the assent of the local authority, and Parliament grants permission to proceed of its own accord. Within the last fortnight the Board of Trade decided it would not exercise the first of these powers, and refused to give licenses to anybody in the metropolis; we are therefore thrown back on the provisional orders. I think the Board of Trade was wise in dealing with such a large question in saying Parliament should have a voice; but, at the same time, I think the Board of Trade would have acted more fairly towards us if they had decided two months earlier, when

* See *The Electrician*, November 9, p. 11.

* See also *The Electrician*, November 2, p. 819.

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we should have been spared the expense of applying for the licenses. We have not to-day presented any accounts. The Board of Trade said that all the accounts were to be made up to the 31st December, and were to be presented before the end of March. If we had put it off till that period twelve months would have expired after our last annual meeting, and therefore it was thought desirable to call our shareholders together to hold our meeting at this time, and to get these accounts forward as rapidly as possible, and then present them at another meeting. I am not at all sure it would not be advisable in future to hold another meeting, dating the period when we present the accounts as the period at which we should hold the annual meeting. As regards provisional orders, there is a certain amount of difficulty which must accrue in future, but our business has been placed very nearly in a unique position so far as the commercial business of this country is concerned. We are providing people and doing certain work permissively to our own ends. We are recognised to a certain extent by the Legislature; but, at the same time, we are bound down and hampered and forced to do many things which it may not be to our interest to do. An ordinary business at the commencement will work slowly and will do everything to ensure the largest possible revenue, and is not bound to do more work than will bring in a dividend in the course of any period; but the Act of 1882 gives power to the local authority, after a certain period of time has elapsed, to say, "You shall do certain works for us now, and if you do not do that within six months there comes a certain amount of fine." Well, we have been negotiating with the local authorities to get that time put back as remote as possible. They all wish to say, "You shall be compelled to do that which we ask you to do," so that the local authorities may require us to run mains into places for their own convenience, and require us to light a street, for instance, which would not pay a remunerative sum for the capital outlaid on the mains. There is only one redeeming point in that, and that is the local authority is bound to promise you for three years that they shall take current to the amount of 20 per cent. on the outlay which is incurred; therefore, it may have a certain amount of deterring influence, and it may be doubtful whether we shall be called upon to do this or not; but still we must struggle to have that put back as far as possible. I have tried to get certain vestries to allow it to be two years. I do not think there is anything more with which I need detain the shareholders. I will simply move that the report be adopted, and after that has been seconded I shall be very happy to answer any questions that any gentleman may ask.

SIR COUTTS LINDSEY seconded the motion. He said that until recently he had been the Chairman of the Company, but he had felt much pleasure in resigning in favour of so eminent a scientist and electrician as the Earl of Crawford. The Chairman had explained the nature of the business, the prospects of the future, and he had also explained the difficulties which had arisen in the starting of this business. He believed that the working of the previous Company was very essential to the success of this Corporation. It was the pilot company, and there was no doubt that in the experiments they made they were not always as successful as they might have hoped to have been. At the same time the ultimate result of the sale of their plant to this Corporation was extremely satisfactory. Lord Crawford had passed them a map of the current of each week, and on that map he believed there was registered a certain value; that value was registered by the Government measure—that was the Board of Trade unit—7½d. per Board of Trade unit. That represented what they were entitled to in payment for their current; at the same time they had had very great difficulty in measuring that current properly, and he thought that Lord Crawford did not mention that they were now in possession of a meter which was simply as near perfection as it could be, and that removed one of their greatest difficulties in the future. In the past they had not been able to claim the full value of their output, because they had no meter, and their arrangements were by the year; now, however, any amount of current they supplied they had a voucher for, and that voucher would represent the value to those who consumed it and to the producers. He had only one more observation to make, and that was as to their Board; he thought it was unusual in most companies that a Board should hold such a large number of shares. He thought it might be a satisfaction to them to know that those who were managing their business had an overwhelming stake in its welfare, and that they on their own part, as well as that of the public, were likely to devote the whole of their attention and time to the advancement of this Corporation. In the past the Board had worked with unremitting attention, and when he resigned the chair, which he did recently, he had the pleasure of seeing Lord Crawford take his place; his lordship was a man eminently fitted to perform the duties of the Company, and to safeguard the Company, both from his knowledge of electricity and general capabilities as a man of business. He (the speaker) resigned his seat with pleasure, feeling that his interests and those of the shareholders were perfectly safe (cheers).

Mr. McLEAY asked whether the Metropolitan Electric Supply Company had applied for provisional orders in the same districts as this Company had asked for them.

The CHAIRMAN replied that in a very large number of cases they were the same.

The resolution was then put and carried unanimously.

The CHAIRMAN: We now come to the second portion of our business, referring to the question of the future financial arrangements of the Company. And here it will be necessary for me to refer to what passed at our last general meeting. The capital of the Company consists of 50,000 fully-paid shares of £5 each, 25,000 upon which £4 have been paid, and £180,000 debentures, which it will be in your memory were created by the resolution at our last meeting. Your Directors were empowered at that time to issue those debentures to a member of their Board, Lord Wantage; he has taken up a certain number of the debentures, and the conversion as at that time suggested has been carried out, and before the end of this year the debenture debt of this Company will be wiped out, and the 36,000 shares that Lord Wantage will receive in exchange for these debentures will be actually paid up in full; therefore, I consider we are in a very happy, comfortable position so far as that is concerned. It may seem strange to some of the shareholders that the Directors ask to increase the capital while there is a certain amount of ordinary capital still in hand; they may also ask, "Why do you want any more money at all at present?" With regard to the money I think I shall be able to satisfy you. With regard to the business done at Deptford, we made the most careful estimates we were able to do, and I think our estimate has come out within a very small amount of what actually we consider will be required for paying for it; but in the money so subscribed for this step we did not feel quite certain at the time we had sufficient to do that which we wanted, and therefore, although we may want £30,000 or £40,000 more than we have cash at the present moment, still we are not that amount wrong in the estimate. I estimate we may require £40,000 in order to complete the works and have machinery going capable of giving simultaneously 150,000 lights, and keep 100,000 in reserve. At the present moment we have let it be known to a certain extent that we shall be in certain quarters of London before very long; we have done this in order to let people know we are coming there, and to feel the pulse of the inhabitants of those portions of the metropolis so as to see what customers we are likely to obtain. The response to our circular, I think, would take up the whole supply that we would be able to put down. If we had 150,000 lights ready now we could place them in the course of next week. I think this is a very healthy position to be placed in. In conclusion, the Chairman said that the Directors wanted power to put up sufficient machinery for 200,000 lights more. He said he thought it would be enormously to the advantage of the Corporation to have such power in their hands. He moved a resolution authorising the increase of capital in the manner suggested.

Lord WANTAGE seconded the resolution, which was carried unanimously.

A vote of thanks to the Chairman and Directors terminated the proceedings.

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Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on the 21st inst., Mr. John Marks presiding.

The SECRETARY (Mr. Samuel J. Boyce) having read the notice convening the meeting,

The CHAIRMAN moved the confirmation of the first resolution on the agenda paper, as follows :—

"*That the Maxim-Weston Electric Company (Limited) be wound up voluntarily.*"

Mr. LOUIS SWABY seconded the motion, which was carried with four dissentients.

The CHAIRMAN next moved the confirmation of the following resolution :—

"*That Mr. John Marks, of 113, Great Russell-street, W.C., Mr. J. M. Klenck, 42, Bishopsgate-street Within, E.C., and Mr. Louis Swaby, of 23, Churchfield-road, Ealing, be and they are hereby appointed liquidators for the purpose of such winding up.*"

Mr. HILDYARD seconded the motion.

Mr. ABRAHAMS observed that at the last meeting, on the 3rd December, there were several resolutions tacked on to the foregoing, and as they were not mentioned as coming up forc onfirmation he presumed they were abandoned.

The CHAIRMAN replied that these were the only resolutions which the present meeting was called upon to confirm.

The motion was agreed to with four dissentients.

The meeting was then resolved into a second extraordinary general meeting, and

The SECRETARY having read the notice convening it,

The CHAIRMAN said that since they last met they had been advised by eminent counsel that the terms on which the liquidators should sell to the new company should be embodied in an agreement, a draft of which he would ask the Secretary to read to the meeting.

The SECRETARY accordingly read the document in question.

The CHAIRMAN observed that in drawing up this agreement the counsel who were responsible for it had paid due regard to the rights of all parties interested in the Company. The principal clause in it referred to the fact that there was to be an allotment of one share in the new company for every share held by a member of the old Company, while due provision had been made for the holdings of the dissentient shareholders. He concluded by moving :—

"*That the liquidators of the Company be and they are hereby authorised to consent to the registration of a new company to be named the Maxim-Weston Electric Company (Limited), with a Memorandum and Articles of Association which have already been prepared with the privity and approval of the Directors of this Company.*"

Mr. J. M. KLENCK seconded the resolution.

The CHAIRMAN, in reply to Mr. Henderson, said that he mentioned at the last meeting that the liabilities of the old Company amounted to between £2,000 and £2,500, and that their book debts, which they looked upon as good debts, were equal to those liabilities, so that they had their patents and plant unencumbered.

A SHAREHOLDER said he would like to know what the Directors were prepared to offer the dissentient shareholders for their holdings, and whether, if there was to be an arbitration as to the value of their shares, it was to be at the cost of the Company.

Mr. ABRAHAMS said he was instructed by the holders of 30,000 shares to intimate their probable dissent from the resolutions before the meeting, and said that they would not be contented with less than 2s. per share, which he thought the arbitrator would award. He had carefully read the agreement, and in all respects he thought it was a very fair one ; but he thought that the 10th clause, which provided for the discretionary retention of the property of the Company by the liquidators until the claims of the dissentient shareholders had been satisfied, ought to be made compulsory.

The CHAIRMAN, in reply to Mr. Abrahams and Mr. Henderson, said that it was provided by the said agreement that the interests of the dissentient shareholders would be submitted to arbitrators, who would determine the value of their shares. In the event of the arbitrators disagreeing an umpire would be called in. With all due deference to the opinion of Mr. Abrahams, he did not think that either the arbitrators or the umpire would estimate the value of the shares of the dissentients at 2s. The liquidators were, however, bound to pay what the arbitrators fixed as the market value of the shares, but he would point out that, under the provisions of the agreement, if shareholders holding more than 30,000 shares should dissent, it would be optional for the new Company to decline to carry out the agreement, and in that case there would be no alternative but to wind up.

Mr. J. M. KLENCK said that the scheme now proposed was in the interests of all the shareholders, who, he hoped, would give their sanction to the carrying of it into effect.

Mr. NEWTON emphasised the fact that the dissentients were only entitled to the value of their shares as determined by arbitration, by the result of which they were bound to abide.

The resolution was carried with six dissentients.

The CHAIRMAN then moved the last resolution as follows :—

"*That the draft agreement submitted to this meeting, and expressed to be made between this Company and its liquidators of the one part, and the Maxim-Weston Electric Company (Limited), of the other part, be and the same is hereby approved, and that the said liquidators be and they are hereby authorised, pursuant to Section 161 of the Companies Act, 1862, to enter into an agreement with such new company (when incorporated) in the terms of the said draft, and to carry the same into effect with such, if any, modifications as they think expedient.*"

Mr. HILDYARD seconded the resolution, which was agreed to with six dissentients.

On the motion of Mr. NEWTON, a vote of thanks was passed to the Chairman, which terminated the proceedings.

Charles L. Baker and Co. (Limited).

The second ordinary general meeting of this Company was held at the registered office, Booth-street, Manchester, on Tuesday last, December 21st, 1888, Mr. J. E. Longson in the chair.

Mr. GEORGE W. LOWCOCK (the Secretary) having read the notice convening the meeting, the report and accounts were taken as read.

The CHAIRMAN said that the Directors had much pleasure in meeting the shareholders and laying before them the accounts of the first year's working. This they considered very satisfactory, considering the business had been in the hands of the company so short a period. They had pleasure is recommending a dividend at the rate of 10 per cent. per annum on the Ordinary shares and 5 per cent. on the Deferred shares. The business of the Company had largely increased, and they were sure that the shareholders would be gratified to learn that they had secured several valuable contracts, which would keep the works fully occupied for some length of time.

Messrs. Trevor and Pilling were re-elected auditors, and a vote of thanks to the Chairman concluded the meeting.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 21st, 1888, amounted to £6,270.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 21st, 1888 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company), were £5,268.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended December 15th, 1888, were £2,790, as compared with £2,807 in the corresponding period of 1887.

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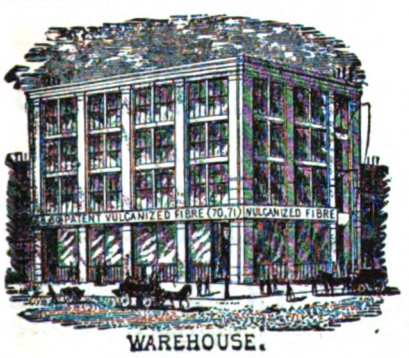

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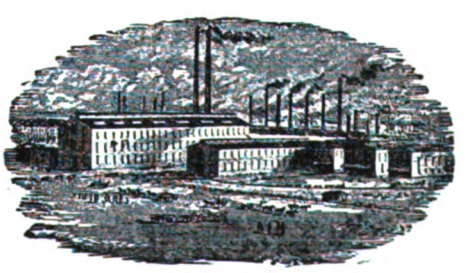
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Monday, Dec. 24, 1888.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Dec. 24, 1888.	
£			**TELEGRAPHS.**		£ s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	47½ 48½	2 16 8	Jan., Apr., July, Oct.	47⅛	46⅛
2,614,820	Stock	15/0	Do. Preferred	79 80	3 8 9	" "	79⅜	78⅞
2,614,820	Stock	nil.	Do. Deferred	16½ 16⅝	...	February	16⅛	15⅝
130,000	£10	5/0	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13⅜	13⅛
16,000	10	9/0	Cuba Submarine	14 14½	5 17 3	February and August	14½	...
6 000	10	10/0	Do. Preference 10%	18 19	5 5 3	" "	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4⅛	3 11 1	March & September	...	...
6,000	5	5/0	Do. Preference 10%	9 9½	5 10 0	April and October	...	...
60,710	20	2/0	Direct United States	9⅛ 9⅞	4 2 1	Jan., Apr., July, Oct.	9⅝	9⅛
380,000	10	2/6	Eastern	12½ 12⅝	4 16 0	" "	12 7/16	12 5/16
70,000	10	3/0	Do. 6 per Cent. Preference	14½ 15	4 2 2	" "	14⅜	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	...	...
250,000	10	2/6	Eastern Extension	12⅜ 12⅞	5 1 0	Jan., Apr., July, Oct	12⅜	12 5/16
22,050	10	8/3	German Union Telegraph and Trust	9 9½	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅜ 7	5 7 2	Jan., Apr., July, Oct.	6⅞	6⅝
178,992	10	3/0	Do. 6 per Cent Preference	14½ 14⅝	4 3 8	" "	14⅝	14⅜
150,000	10	5/0	Great Northern	14½ 15	5 0 0	Jan., July, and April	14⅞	...
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
38,348	10	3/0	London Platino Brazilian	7½ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7	5 10 6	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	...	West African Telegraph	7 8	...	...	...	...
300,000	100	...	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	...	...
30,000	10	6/0	West Coast of America	9 9½	5 5 3	January and July	9½	...
150,000	100	8%	Do. Debentures 8%	121 125	6 8 0	June and December	...	...
88,321	10	1% '78	West India and Panama	1⅝ 1⅞	...	...	1⅝	1 13/16
34,563	10	12/0*	Do. 1st Preference 6%	11½ 11⅝	5 2 2	April and October	11⅝	11 7/16
4,669	10	†	Do. 6 per Cent. 2nd Preference	11⅞ 12⅛	...	...	...	...
45,181	15	6 0	Western Brazilian	13½ 13⅝	5 11 0	March & September	13½	...
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	£5 7s. '87	Consolidated Telephone and Maintenance	⅜ ⅝	...	Yearly	...	...
220,000	£1	2½%'87	Oriental (11s. paid)	1/16 1/8	...	...	1/16	...
80,000	5	5/0	United	13½ 14½	5 5 3	June and December	14 1/16	13⅞
55,000	5	4/6	United River Plate	5⅜ 5⅝	...	January and July	5½	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3⅜ 4¼	...	...	3⅞	...
23,692	5	nil.	Do. (fully paid)	4⅜ 5⅛	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2 9/16	2⅜
312,000	¼	5% '86	Maxim-Weston	1/16 3/16	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	40 41	5 17 2	March and July	41	40⅞
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17½ 18	5 11 1	February & August	17⅝	...

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 555.—Vol. XXII. FRIDAY, JANUARY 4, 1889. Price 4d.

NOTES.

It needs hardly to be said that the inaugural address which will be delivered on Thursday evening next by Sir William Thomson, as President of the Institution of Electrical Engineers, is awaited with keen expectation throughout the scientific world as an event of the very first importance. Whatever Sir William may have to say, whether on the physical aspects of those recondite mathematical studies which he has made peculiarly his own, or on the practical applications of scientific knowledge, will be followed with the same degree of attention. We think that it will be found that a large portion of Sir William's address will be devoted to a consideration of the probable and the ascertained relations betwixt ether, electricity, and ponderable matter. Questions relating to the propagation of electro-magnetic and electro-static induction, to which the researches of Hertz and the discussions at the recent meeting of the British Association have lent renewed interest, will probably be touched upon. The conditions of stability of molecular rotations and their connection with magnetic and electro-magnetic phenomena will be illustrated by reference to experiments with the gyrostat. But whilst we may confidently anticipate that Sir William's address will throw new light upon these dark places, yet we believe it will be found that he feels himself driven to the conclusion that any wholly satisfactory and comprehensive theory is beyond our present powers of imagination.

Speaking of Sir William Thomson one thinks naturally of the mariner's compass, and this reminds us of a singular rumour of which we have recently heard, to the effect that the use of the compass is about to be altogether superseded. A method is said to have been discovered by which the true North may at any moment be ascertained by means of a device which is wholly independent of magnetic action. The reading is, however, obtained by electrical means, and it is said that a well-known Berlin firm of electricians has secured the patents. Our informant also surmises that gyroscopic action is involved. We mention the story for what it may be worth.

Some misapprehension appears to exist as to the motives for the action which the Board of Trade has taken in reference to the applications for licenses for the supply of electricity within the Metropolitan area. We therefore publish in another column the text of the memorandum, and it will be seen that the Board is merely anxious to escape the responsibility which the issue of a license would devolve upon it. On the whole, we think that this action is to be regretted. It is within the power of the Board of Trade to create licenses for any lesser number of years than seven, and if they would issue licenses for terms of one, two, or three years, by the time these had expired the question would be ripe for Parliamentary decision on the basis of an order extending for the full term of forty-two years. Probably one reason which has induced the Board to take this step is the difficulty which it still experiences in determining whether or not more than one license or order is to be granted for any given area. As matters stand the ultimate decision as to the fate of the huge schemes now in progress will be in the hands of a Parliamentary Committee, who will have the advantage of hearing arguments for and against the proposals, but who will not be in possession of material evidence upon their practical working such as a somewhat bolder policy on the part of the Board of Trade might have provided them with.

Mr. Beeston, of the House-to-House Electric Lighting Company, casting about for the most dignified means of communicating his private opinion upon the Deptford scheme, happily bethought him of being "interviewed" by a reporter of a financial paper. Mr. Beeston is well assured that both technically and commercially the London Electric Supply Corporation is altogether on the wrong road. Well, time will show; for our own part we do not care to prophecy until we know a good deal more than anybody—except, apparently, Mr. Beeston—does at present. We quite agree with him, however, in the belief that "there is no big monopoly in store in electric lighting." We also recognise the fact that the House-to-House, in common with other companies who are working on well ascertained lines, are fully entitled to claim public confidence on the ground that their proposals are not of an experimental character.

In *Wiedemann's Annalen*, Herr R. Von Helmholtz describes a pretty and singular experiment. A jet of steam escaping from a hole one or two millimetres in diameter is lighted obliquely and observed upon a dark background. The jet is then invisible at the base and whitish at the top. But if a pointed wire connected with a static induction machine be brought near, the jet immediately assumes a brilliant tint, whose colour depends upon the potential of the point. The same effect is produced without the aid of electricity by merely

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holding a heated body near the jet. The phenomena is due no doubt to a modification of the size of the particles of aqueous vapour, and in the hands of Prof. HELMHOLTZ we may expect the experiment to throw new light on some of the most difficult problems of molecular physics.

SINCE writing the above Mr. A. E. MAYOR, who at one time held the appointment of Chief Electrician in the Chilian Navy, has informed us that he has frequently observed the effect described when a beam of electric light has been thrown upon a cloud of steam. For naval purposes this plan of blowing off steam and projecting the beam upon the cloud forms a most efficient method of signalling, and in action it is much better than any device involving the suspension of lamps from the yard-arm, since it does not reveal the exact position of the ship to the enemy. The latter method, however, is in vogue in the French, Spanish, and American navies, and recently Commandant ARDOIS, of the Spanish service, has devised an improvement on the Conz system, which latter was described in *The Electrician*, August 3rd, 1888, p. 401. The Ardois system enables any one of sixty-two different combinations of five red and five white lamps to be effected by a single movement of the commutator. A full description of the device will be found in the *Révue Industrielle* of the 22nd ult.

AN engineering contemporary mentioned last week that Messrs. GOOLDEN AND CO. "have proposed to connect the search lights of war vessels with the sights of the quick-firing guns in such a way that when the light is bearing on an object the gun is also. In this way they expect to save time when every minute is of importance, as it is during the approach of a hostile torpedo boat." This application of the search light is, however, of even greater importance in the case of heavy guns and long ranges than in the case of short range, quick-firing guns; but it is also attended with much greater difficulty. The straight line of light does not in this case coincide with the trajectory of the shot, and when it is also recollected that the gun is fired from a rolling platform, it is evident that before the method can be of any use some means must be provided for applying a correction suited to the range, and this correction must also be well-nigh instantaneous. We happen to know that this question has for some time occupied the attention of our own engineers. In the Chilian navy, however, Mr. MAYOR some time ago achieved remarkable success with this method of firing, and we believe that he had also an electrical device which ensured firing on an even keel. We hope shortly to publish some further information on these points.

WE learn with considerable satisfaction that the Patent Office is about to resume the publication of the excellent series of classified abridgments of specifications, the preparation of which has been practically suspended for some years. The arrears of the work are, however, enormous, and a large staff of special abridgers is now being organised, in the hope of eventually bringing the undertaking down to date. The electrical patents are divided into six sections, and unfortunately not one of them is brought to a later date than 1876, so that they stop short exactly at the point where the modern developments may be said to have commenced. We do not know whether the Patent Office has yet completed the selection of its staff, but considering the importance and the difficulty of the task before it, we trust that steps have been taken to secure thoroughly competent men for the work. It may not be out of place if we add that approved applicants are permitted to take the work away with them to be done at their own convenience, the payment being at the rate of 5s. for each specification, irrespective of its length.

THE abridgments of electrical specifications from 1766 to 1876 (which may be obtained at a total cost of only 13s. 8d.) are classified in six divisions, as follows:—I. Generation of Electricity and Magnetism; II. Conducting and Insulating; III. Transmitting and Receiving Signals; Controlling Mechanical Action and Exhibiting Electric Effects; IV. Electric Lighting, Igniting, and Heating; V. Electro-Deposition and Electrolysis; VI. Electric Motive Power Engines and similar apparatus. This classification may have been very suitable up to 1876, but we sincerely hope that the Patent Office will recognise the fact that it is no longer capable of meeting the requirements of the case. A very different and much more detailed classification is, indeed, absolutely necessary for the efficient carrying out of the scheme; and this is a point to which the compilers should give the fullest consideration.

THE Bill for Technical Industrial Education which has been introduced in the local Kensington Parliament by Prof. PERRY, and to which we have given all the publicity our pages will afford, is to be commended at all events for the directness and simplicity of its provisions. Shorn of formalities, the Bill enacts that School Boards shall provide technical schools; that boys and girls employed in workshops shall attend these schools; and that the employers shall pay the fees. These are rather startling propositions, and anywhere else but at Kensington they would probably have a warmer reception than the promoters seem to bargain for. A Kensington Parliament, however, ought to be composed of educated and intelligent men; and we doubt not that Prof. PERRY'S Bill will receive that criticism which in his letter to us he frankly invites. If any of our correspondents conversant with the needs of industrial life also care to respond to that invitation through our columns, we shall be pleased to hear from them.

Our influential and important contemporary the *Municipal Review* came out the other day with some very unkind remarks on what it is pleased to call "Electric Lighting Botchers." That there have been botchers, and more unhappily still, that there *are* botchers, in electric lighting (as well as in journalism and a few other professions) cannot be denied. But the *Municipal Review* says that all promoters of electric lighting, at least in London, are "a sorry lot." And what "is surprising," our contemporary proceeds, "to people who are accustomed to think for themselves is the want of ingenuity and

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originality displayed." Everyone is, of course, aware that the intellectual development of the average electrical engineer is of a singularly low order, otherwise he would not have to come to the *Municipal Review* to be taught his business. Central lighting stations constructed according to the methods now in vogue, according to the same authority, "can readily ruin any neighbourhood"; and what ought to be done is to give up the use of steam and resort exclusively to artesian wells as a source of motive power. This is a grand idea; and as for some trifling practical difficulties which suggest themselves to the benighted electrician, doubtless our contemporary knows exactly how to overcome them. Hitherto it has been thought that artesian wells are only attainable under certain special geological conditions; but this is perhaps a mistake. (By the way, the well at La Chapelle, in Paris, which is now used as a source of motive power for electric lighting, took only 24 years to dig.) Finally, our contemporary says that it is a disgrace to our "bosted" (*sic*) civilisation that the lighting of London by electricity should be left to chance, and thinks that "no time should be lost in establishing a central authority composed of men acquainted with the subject and the wants of the people of to-day." Would it not be better still to entrust the whole business to the editor of the *Municipal Review*?

We would call special attention to the announcement that Prof. Perry proposes to give a working knowledge of the Differential Calculus in a special course of twelve lectures and exercise work to electrical and mechanical engineers. It is to be hoped that this opportunity will be welcomed by a large number of those who have only an elementary knowledge of algebra and trigonometry. Men of this class usually grow disgusted when they see a sign of integration or differentiation, and yet they are continually using the ideas of the Calculus without knowing it. The first lecture will be given at the Finsbury Technical College on the 15th of January, at 7 p.m.

The *Gas World* "thinks that whenever an electric company applies for powers to supply a certain area their claims should be resisted by some recognised organisation." Poor *Gas World*!

Bedford.—The Town Council of Bedford has granted £25 to a committee of inquiry as to electric lighting.

Restoration of Telegraphic Communication with British Guiana.—We are informed that the cable between Trinidad and Demerara is now opened.

Proposed Electric Lighting at Bishop Stortford.—A proposal is on foot in this town to form a local company for electric lighting purposes, with a capital of £10,000 in £5 shares.

Election Intelligence.—Sir John Pender, K.C.M.G., Chairman of the Eastern Telegraph Company, is the Unionist candidate for the Govan Division of Lanarkshire, in the vacancy created by the death of Sir W. Pearce.

The Electric Light on Torpedo Boats.—The Austrian naval authorities are using Parsons's turbo-electric generators on board their torpedo boats. The dynamo runs at 10,000 revolutions a minute, and develops 28,000 watts.

Calendars for 1889.—We have received some artistic and useful calendars for the New Year from the Anglo-American Brush Corporation, the Commercial Cable Company, and the Direct United States Cable Company.

Barnet.—At a meeting of the Barnet Local Board, held on Tuesday evening last, the resolutions antagonistic to Mr. Joel, which had been passed at the previous meeting were rescinded, and a cheque for the last quarter's lighting was handed to Mr. Joel.

Folkestone.—It will be seen in our advertisement columns that the Electric Lighting Committee of the Corporation of Folkestone have been authorised to enter into a provisional contract for lighting a part of the town with arc lights. Tenders must be sent in by the 23rd inst.

The Telephone at the Paris Exhibition.—The Société Générale des Telephones will place exhibitors at the forthcoming International Exhibition in telephonic communication with their Paris system, at a charge of 300fr. The service will commence on 1st May and continue to the close of the Exhibition.

Dundee.—Messrs. Gilroy, millspinners, of Dundee, have laid an underground cable between their calender and their jute sheds, a distance of 200 yards. The current generated by the dynamo at the calender is used to drive a motor at the jute sheds, which works the lifts and other machinery. The current is also used for lighting purposes.

Academie des Sciences.—The prize which the Académie des Sciences has offered without result for several years in succession for some important advance in the theory of the electrical transmission of power has this year been withdrawn on the suggestion of MM. Deprez, Bertrand, Mascart, Becquerel, and Maurice Levy, who formed the committee of award.

"Electricity at Work."—An interesting lecture under the above title was recently delivered at Georgetown, British Guiana, by Mr. S. Vyle, Government Electrician. A large audience, including the Governor, was present. During the lecture telegraphic messages were sent and received from New Amsterdam and Trinidad, and the electric light was shown and explained.

Portsmouth Dockyard.—The *United Service Gazette* says that plans are being prepared for the erection of an electric lighting station near the present electric lighting shop at Portsmouth Dockyard which will transmit electricity for lighting purposes to the ships fitting in the repairing basin, and also to the new battle ship which is to be built in No. 13 dock during the next financial year.

The Telegraph in the South African Gold Fields.—The activity in the mining shares of the Witwatersrand Gold Fields has recently increased to such an extent that the telegraph office at Johannesburg has been overwhelmed by the number of messages between that centre and other South African markets and with London. A foreign mining journal says that as an average the number of despatches is 1,000 daily, and the daily receipts have been as much as £200.

City and Guilds of London Institute Old Students' Association.—The question of the further issue of a *Journal* has been under consideration of the committee for some time past, and it was finally resolved at the meeting of Dec. 18th to bring out jointly with the Central Institution and the Technical College, Finsbury, a *Journal* to represent these colleges and the Old Students' Association. A circular and subscription forms will shortly be posted to members, and it is hoped that all will become subscribers.

Telegraph Development in the River Plate.—The following table, showing the growth of the telegraph receipts of the River Plate for the ten years ended December 31, 1887, is taken from the official report:—

Year.	Revenue.	Year.	Revenue.
1878	$81,000	1883	$223,000
1879	95,000	1884	167,000
1880	114,000	1885	244,000
1881	118,000	1886	248,000
1882	221,000	1887	407,000

Electricity at Horsington.—At an Art, Scientific and Industrial Exhibition recently held at Horsington, an interesting display of the varied uses to which the electric current can be put was made under the superintendence of the Rev. J. D. C. Wickham, rector of the parish. A battery of accumulator cells was carted from the rectory to the school room where the exhibition took place, and supplied a large number of lamps to light the rooms

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and approaches, besides driving motors. The cells were charged by a dynamo lent by the rector, and the electrical portion of the exhibition attracted the greatest attention and interest.

Society of Arts.—The following arrangements have been made for the Wednesday evening meetings of the Society of Arts after Christmas:—On the 23rd a Paper will be read by Prof. George Forbes, on "Electric Meters for Central Stations." Papers for which dates have not yet been fixed will also be read on the "Manufacture of Aluminium," by Mr. William Anderson; on "Secondary Batteries," by Mr. Preece; on "Automatic Selling Machines," by Mr. J. G. Lorrain; on "Arc Lamps and their Mechanism," by Prof. Silvanus Thompson; and on the "Use of Spirit as an Agent in Prime Movers," by Mr. A. F. Yarrow.

The Proposed Underground Electric Railway.—Mr. Gainsford Bruce, Q.C., M.P., presided on Wednesday at a meeting of the ratepayers of Holborn, in opposition to the proposed line of underground electric railway between Piccadilly and Holborn-circus. Mr. L. Isaacs, M.P., described the railway as one which commenced nowhere and which ended nowhere. Mr. R. R. Hazard, one of the directors of the company, denied that the line would interfere with the sewers or the gas or the water. A resolution was passed in opposition to the scheme, and a committee was formed in order to take steps for opposing the London Central Subway Railway Bill in Parliament.

The "Brockie-Pell" Arc Lamp.—We learn that after using forty of these lamps for about three years at the Royal Laboratory, Woolwich, the Government have given an order to Messrs. Johnson and Phillips for twenty more to light the new saw mill at the Arsenal. The same firm have also recently shipped a large number to Australia for the purpose of lighting nearly three miles of streets in one of the principal towns in New South Wales. The "Brockie-Pell" lamp being now so well and favourably known, we are not surprised to hear that the demand generally this winter has been so great that Messrs. Johnson and Phillips, who are the sole makers and licensees, have had to considerably extend their workshops in this department

The Institution of Civil Engineers.—The following table shows the progress of this society (incorporated by Royal Charter) during the last decade and the past twelve months, the date given, the 2nd of January, being that of the establishment of the institution in the year 1818:—

January 2nd.	1889.	1888.	1879.
Members	1638	1596	1081
Associates	3003	2855	1717
Honorary Members	18	20	16
Students	957	947	535
Totals	5616	5418	3349

Long Life in an Incandescent Lamp.—The Bigelow Carpet Company, of Clinton, Mass., U.S.A., have been operating a Brush incandescent electric light plant since 1885. Some of their Swan incandescent lamps have made wonderful records in the length of their burning hours. They have recently forwarded a lamp to the parent company in Cleveland, which they commenced using on January 25th, 1886, since which time it has burnt 7,400 hours, having been in use in the dynamo room, and has not been turned off over half a dozen times since it was placed in position. It has been left in circuit, and been always lighted whenever the dynamo was running. The lamp is not as yet burnt out, nor blackened in any way. It is still burning in the Brush offices in Cleveland.

New Catalogues.—We have just received a copy of Messrs. Woodhouse and Rawson's new catalogue, which seems as replete as ever with illustrations and descriptions of every sort of electrical fitting. Amongst other things we notice a large variety of the well-known Woodhouse and Rawson incandescent lamps, and some very artistic illustrations of electric brackets, standards, and electroliers.—The Edison and Swan United Electric Light Company have also just issued a new price list, containing a good deal of information about the numerous lamps and lamp accessories which the company supplies. We have also lately received the new illustrated catalogue of the United Asbestos Company, which makes a speciality of Italian as well as Canadian asbestos. The prices seem to compare very favourably with those of other manufacturers.

The Lighting of the City.—At the various Wardmotes held in the City on Friday, the 21st ult., a few references were made to the lighting of the streets by electricity. At the Aldgate Wardmote the following resolution was passed:—"That this Wardmote is of opinion that the time has arrived when the City should be illuminated by the electric light, and regrets the slow progress heretofore made in accomplishing this. They therefore hope the members of the ward who are members of the Commission of Sewers will exert themselves to obtain the carrying of it out, and as quickly as possible." At the meeting of the Bread Street Ward Mr. Alliston, one of the representatives re-elected to the Court of Common Council, said he thought the lighting of the City by electricity, and the abatement of the smoke nuisance, should receive consideration.

Electricity in our Homes and Workshops.—A popular lecture, entitled "Electricity in our Homes and Workshops," was recently delivered at Norwich by Mr. Paris, of the firm of Laurence, Paris and Scott. The lecture was of a most interesting nature, and was largely illustrated by practical experiments. Mr. Paris laid great stress not only upon the beauty and manifold advantages of the electric light, but upon its harmlessness. The lecturer stated it as his opinion that there was a great future before electricity as a motive power, and that he looked forward with confidence to the day when many industries which are now carried on in huge factories would employ people, as of old, in their own homes. A hearty vote of thanks was accorded to Mr. Paris, who, in acknowledging it, repudiated the idea that electricity was in its infancy; it was no longer an infant, but a vigorous youth.

Progress in New Zealand.—The *New Zealand Herald* says that Mr. Horton, the newly-appointed electrician of the Reefton Electric Light Company, "recommends the substitution of Swan-Edison incandescent lamps for those of Thomson-Houston manufacture, at present in use by the company. He says the lamps are altogether unsuited to dynamo. (!) He further recommends the use of overhead wires in place of an underground cable, and if these changes are effected he assures the directors there is not the slightest doubt in the world of the complete success of the installation. He is well pleased with the design and condition of the plant otherwise, and has expressed the opinion that the dynamo has a full capacity for 500 lamps. The company have sent to Melbourne for the required new plant, which will be shipped as quickly as possible. Confidence is again re-established in the venture."

Mr. Gisborne on Telegraphy and Telephony.—Mr. F. N. Gisborne recently gave an interesting lecture before a large audience at the McGill University, Montreal. Mr. Gisborne informed his hearers that his desire was not to entertain those present, but to so clearly explain the first principles of telegraphy, telephony, the localisation of breaks in ocean cables, and lightning, that every person present might leave the hall with a satisfactory knowledge of the basis of modern electrical apparatus and inventions. By aid of large diagrams the various telegraph instruments, the Bell telephone, and the dynamo were explained in such simple and non-technical language as to call forth repeated applause from all present. Mr. Gisborne also referred to the endeavours which had been made in the past to establish direct cable connection between England and Canada *viâ* the Straits of Bell Isle. Another attempt was about to be made, and Mr. Gisborne believed the Dominion Government would regard such a movement with favour. The lecture was received with great applause.

Edinburgh Association of Science and Art.—A meeting of this Association was held recently, at which Major-General Sir R. Murdoch Smith delivered a lecture on Telegraphic Communication with India. He gave a general account of the efforts which had been made subsequent to the outbreak of the Indian Mutiny to establish telegraphic communication with the country, and the difficulties that had to be overcome before success was achieved. Of all the great inter-continental telegraphs it was by far the greatest importance to the general in-

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terests of the empire. This would be the case even if India alone were concerned, but its importance was greatly enhanced by the fact that upon that system depended our telegraphic communication with the Australian Colonies, Burmah, the Straits Settlements, the East Indian Archipelago, China and Japan. It was the first system of the kind successfully established, and one reason for his dealing with the matter was that from its first beginning, about twenty-five years ago, until quite recently, he happened to be perfectly familiar with its history.

The Telephone and the Fire Brigade. — The National Telephone Company have received from the Watch Committee of the Birmingham Corporation a well deserved recognition of the usefulness of the telephone to the police and fire brigade departments. The committee's letter says:—"Not only are subscribers able to convey information of the outbreak of fire on their own premises, but on several occasions fires occurring in the neighbourhood of a telephone subscriber's office have been reported to the Central Station, and the delay which might otherwise have occurred, and which is so disastrous, has been avoided. The sub-committee consider this not the least of the many advantages which your system offers, and in proportion with the extension of the system will the benefits referred to be increased." It may be added that recently an outbreak of fire took place at the Britannia Railway Carriage and Waggon Works, a distance of one and a-quarter miles from the Central Fire Station. The men in charge telephoned to the fire station at once, and in nine minutes from the despatch of the message the steam fire engine arrived at the scene of the outbreak.

New Street Fire Alarm.—Mr. George Durham, of Stockport, has just completed a service of street fire alarms, of his own design, for the Stockport Corporation. The apparatus combines electric and telephonic communication with the police station, and the alarm is given automatically. Like other instruments of its kind it is contained in an iron box. In the lower part of the door is a small pane of glass, against which a button presses from the inside. To make use of the instrument it is necessary to break the glass; this at once releases the button, and completes the circuit. A simple arrangement of dials enables the person at the police office to tell from which alarm box the signal comes. A special feature of this apparatus is the variety of ways in which it is possible to complete the circuit should the button by any chance fail to do so. The telephonic apparatus is available as soon as the door of the box is opened. There are twelve of these alarms in Stockport, which have so far worked to the satisfaction of the Corporation, signals being sent and answers received in from three to six minutes. Should the machines continue to act satisfactorily they will probably be increased in number.

Central Station Lighting at Derby.—The following tariff of charges per annum which Messrs. John Davis and Son propose to adopt at their Derby central station, referred to in *The Electrician* of December 21st, may prove of interest:—

INCANDESCENT LAMPS.

Nominal C.P.	Dusk till 8 p.m.	Dusk till 9 p.m.
	£ s. d.	£ s. d.
10	1 5 0	1 15 0
20	2 0 0	2 15 0
32	3 10 0	5 0 0
150	8 10 0	11 10 0
200	10 10 0	14 10 0
300	12 10 0	16 0 0
500	20 0 0	30 0 0
ARC LAMPS.		
. 400—500	14 14 0	18 18 0
1,000	18 0 0	24 0 0
1,500	25 0 0	35 0 0

The Telephone at the Stock Exchange.—The first day's experience of the use of the telephone in the Stock Exchange (says the *Financial News*) has been very successful. The introduction of this important means of facilitating business has been brought about under the auspices of the Exchange Telegraph Company; but the system is actually worked by the United Telephone Company, who are entitled to whatever credit arises out of the working. It will require some little time before the system can work with the perfection which is required; but the arrangements made are very satisfactory and sensible. A portion of the cloak room at the foreign door of the "House" has been devoted to the telephone service, and there 12 sound-proof boxes have been erected. The *modus operandi* is this: When a member desires to speak from his office to anyone in the "House," he calls up the Stock Exchange and mentions whom he wishes to speak to. A waiter has been put in charge of the telephone room, and he has speaking tubes to all the different doors of the "House" where members are called. When anyone is called for over the telephone this waiter speaks to the waiter at the proper door, who summons the member in the usual way, with the addition of a sign which is to be recognised to mean "telephone." The member or clerk then goes to the call office, is told the number of the person desiring to speak with him, and that is all. The process appears to be cumbrous, but it is necessary, and it works very well.

The International Congress of Electricians, 1889.—The organising committee of the International Congress of Electricians met at Paris on Dec. 17th and settled several important matters, amongst others the rules and regulations relating to the forthcoming gathering. The following are some of the most noteworthy points:—Article 2. The Congress to last eight days. Article 3. All persons will be considered members of the Congress who have given in their names to the president of the organising committee before the opening of the meeting, or who put their names down during the session, and who have paid their minimum subscription of 20 francs. Article 5. At its first meeting the Congress will immediately proceed to form its bureau. Article 6. The bureau of the Congress will arrange the distribution of the work of the meeting, will fix the programme for each day, will direct the discussions, and edit the reports. Article 7. Members of the Congress alone will have the right to take part in the sittings, to present Papers, and to join in the discussions. Article 10. The reports will be printed and distributed among the members of the Congress. Article 11. A detailed report of the work of the Congress will be published under the direction of the bureau, and each member of the Congress will have the right to a copy of this report.—The organising committee also definitely decided on its programme (see *Electrician*, December 14th). All communications relating to the Congress should be addressed to M. Mascart, president of the organising committee, 176, Rue de l'Université, Paris.

The Projected Electric Lighting of Cowpen.—About 120 owners of property and ratepayers resident in Cowpen have signed a petition against the adoption of the electric light in the township, and it has been forwarded to the Board of Trade. The petitioners say that they are informed that the Cowpen Local Board have entered into an arrangement with Messrs. Nicholson and Jennings, electrical engineers, of London, to light the district, or some portion of it, with the electric light, notwithstanding that it has hitherto been efficiently lighted with gas, and that all the gas lighting plant is fixed in the streets ready for use. They believe the electric light to be quite unnecessary, and that it will be exceedingly costly in comparison with gas lighting. They also understand that it is the intention of the Board and Messrs. Nicholson and Jennings to proceed immediately with the electric lighting, and not to seek any license or Provisional Order from the Board of Trade until after some system of electric lighting has been installed. Understanding that electric lighting can only be adopted after statutory powers have been obtained from the Board of Trade, the petitioners pray the Board to intervene by initiative in this matter, and order further proceedings to be stopped until the Board shall have held a public inquiry into the matter. At the last meeting of the Cowpen Local Board a petition in opposition to electric lighting was presented from the Blyth Property Owners' Association, in which they pointed to the danger of the town remaining in darkness, and also to the fact that in other towns electricity had been tried and abandoned, and furthermore that gas was cheaper.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 216.)

By the help of the same apparatus Blaserna investigated the rise of a current in a coil when the same is placed suddenly in connection with a constant source of electromotive force. For the "make" extra current only one of the revolving interrupters was used, and the circuit was completed by this means of a battery, galvanometer, and coil. When the commutator was revolved it first started the current and then after an interval cut it off again, and the effect on the galvanometer is due to the sum of all these small quantities of electricity so cut off and integrated whilst the current is in process of increasing. As the duration of the time of contact was increased the galvanometer deflection increased (speed of revolution remaining constant), but when the time of contact was long enough to fully establish the current, then increase of speed of rotation did not increase the galvanometer deflection. By this apparatus the fact was established that the primary current established itself in its coil by a series of oscillations.

Similarly, on breaking the circuit the course of the current was investigated. For this purpose one revolving interrupter, I, was inserted in the circuit of a battery, B, and coil C, and from the ends of the coil (*see* Fig. 17) other wires were brought and led through the galvanometer G, and other interrupter I', arranged as a shunt on the coil. The break in the battery circuit at p was so arranged that each time the current was fully established before being broken again. The break in the galvanometer or shunt circuit was so arranged relatively to the other that the shunt circuit was closed a little before the

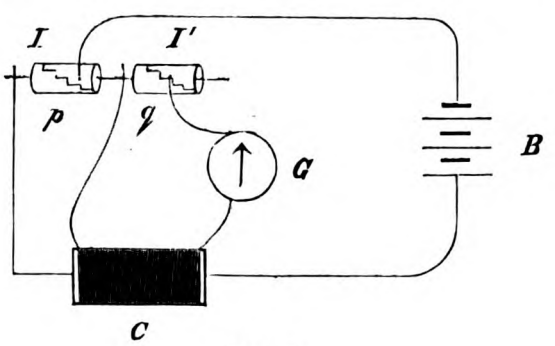

FIG. 17.

battery circuit was broken, and then opened at a definite interval afterwards. In this way there was a little flow of current through the galvanometer due to the steady current, but this could be estimated and allowed for. On plotting out a current curve from the quantity curve it was found that the current decayed away on interrupting the circuit by a series of oscillations which followed each other much quicker than those on the establishment of it, and the whole duration of the extra current at "break," or the time of falling from steady current to practical zero was less than the time required to fully establish the current. It was found that the first oscillation, on beginning to interrupt the steady current, had a much greater amplitude than any of those on starting the current.

The duration of an oscillation was perhaps three or four ten-thousandths of a second, and about 50 to 100 oscillations probably happened before the current became steady; hence the whole duration of the variable period, or of the extra current, was about two to three-hundredths of a second. Very roughly, the nature of the oscillatory character of the current at the make and break might graphically be represented by the diagram in Fig. 18.*

Blaserna drew from his observations the deduction that there is an interval of delay in the starting of the secondary currents, and that a small but measurable time elapses between the instant of making and breaking the primary circuit and the beginning of the secondary current. From this he made a calculation as to the velocity of electromagnetic induction, and he also stated that the interposition of dielectric substances such as glass or shellac between the coils reduced the so calculated velocity.

Bernstein (Pogg. *Ann.*, Bd. CXLII., p. 72, 1871) repeated these observations of Blaserna, but did not confirm these last results. He found that the first oscillation always began at the instant of breaking or making the primary circuit, and he found no effect produced by the interposition of dielectric media.

Helmholtz has carefully examined these results of Blaserna and criticised them.* He remarks that Blaserna used for his coils flat spirals of wire with many turns, and also he used the current from several Bunsen cells to create the primary current. Not only do the spirals act like a condenser, giving the whole apparatus a sensible electrostatic capacity, but the use of a battery of high electromotive force causes a considerable spark at the break, which spark has a very sensible and rather irregular duration. Also in Blaserna's experiments, the two circuits were placed at various distances apart. If a current is started in a primary coil the effect of the induced current created in the secondary by its re-action on the primary is to hasten the rise of the primary current, and at the break to accelerate its decay. As the secondary circuit is moved further off this effect is less marked. Hence, the rise and fall of the primary is more gradual and the arrival of the secondary cur-

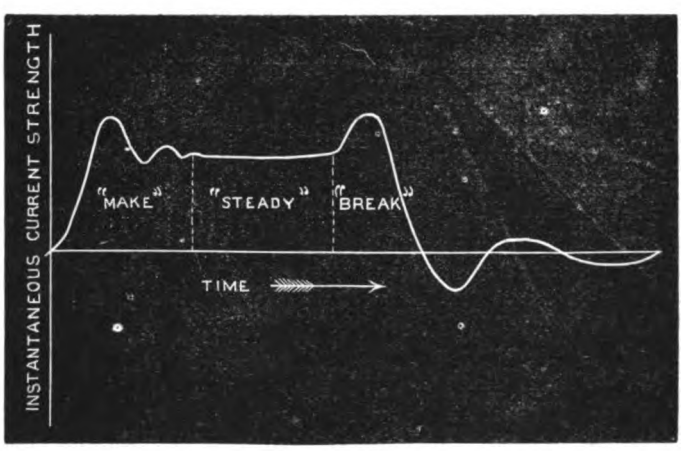

FIG. 18.

rent at its maximum value is more delayed. From this results, then, an apparent retardation of the time of the arrival of the maximum of the induced current.

Helmholtz conducted a series of experiments by means of his pendulum chronoscope. A heavy iron pendulum, P (*see* Fig. 19), the lower end of which carried two plates of agate, could be made to execute one swing and then be caught by a detent. These plates of agate in the course of the swing were caused to strike against and tip over two little levers l, l'. One of these levers was fixed, and the other could be moved forward so as to make the blows successive. One was made to break the circuit of a primary coil, *Pr*, when tipped over, and the other by its movement separated a connection between a condenser and the ends of a secondary coil, *Sec*, attached to it.

These being arranged, the fall of the pendulum executed these two "breaks" successively, and by an interval of time capable of being calculated from the known motion of the pendulum. The two circuits were placed 170 centimetres apart. The primary consisted of 12 turns of thick wire, and the secondary of 560 turns of fine wire. The current was sent from one Daniell cell. The two ends of the secondary were connected to the two plates of the condenser, and when the pendulum fell it broke the primary current and started in the secondary circuit an oscillatory current reverberating to and fro in the secondary wire, the condenser acting as a resonator. At a definite interval

* In *The Electrician* for June 1, 1888, a curve is given by Mr F. Higgins, showing the rise of current in the magnets of type-printing telegraphs, and the oscillatory character of the current at starting is well marked. Mr. Huggins's curve gives the results of actual observations.

* Helmholtz, "On the Velocity of the Propagation of Electrodynamic Effects," *Phil. Mag.* Ser. 4, Vol. XLII., 1871, p. 232.

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after rupture of the primary the condenser was separated and examined by a Thomson electrometer. The charge in the condenser showed the *phase* of the electrical oscillation existing at the instant of such separation. In one case Helmholtz observed 35 oscillations in $\frac{1}{80}$th of a second. In order to discover if any retardation took place with increased distance of the coil, it was necessary to fix attention upon some phase in the oscillations. The successive zero points of the current were very sharply defined, and suitable for this purpose. Helmholtz found that alteration of the distance between the primary and secondary coils made no perceptible difference in the position of the zero points, and that, as far as the apparatus he was using could detect, the velocity of the electro-magnetic impulse must be greater than 195 miles per second. He pointed out in this paper that the commencement of the secondary current is not a sharply marked thing. The spark which takes place at break of the primary lasts an appreciable time, and all this time the primary is dying gradually, and the induced current therefore is increasing. The period of duration of the break spark may be something like $\frac{1}{15000}$th to $\frac{1}{16000}$th of a second, and is, therefore, a large fraction of the duration of a single electrical oscillation, which amounted to about $\frac{1}{2811}$th of a second. The

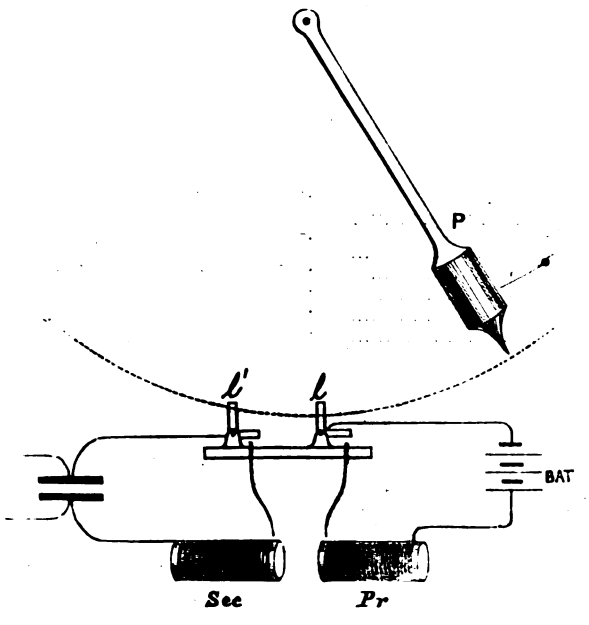

FIG. 19.

duration of the break spark can be found by observation of the time which elapses from beginning of break up to the first zero point of the secondary current oscillations, as compared with the mean value of the duration of an oscillation. The interval up to the first zero point is the duration of the break spark *plus* the time of half a complete oscillation. The duration of the spark is never constant, and depends a good deal on the amount of platinum thrown off from the contacts each time. The average duration of the spark in Helmholtz's experiments was found to be about one-tenth of the whole period of an oscillation. Helmholtz also noticed in some earlier observations evidence of electrical oscillations set up in a flat spiral, one end of which was insulated. In this case some 45 oscillations were detected in the space of $\frac{1}{80}$th of a second. Prof. Henry also noticed that the time of subsidence of the current, when the circuit is broken by means of a surface of mercury, is very small, and probably does not much exceed the ten-thousandth part of a second. It has, however, a quite appreciable duration, for Prof. Henry found that the spark at ending presents the appearance of a band of light of considerable length, when viewed in a mirror revolving at the rate of six hundred revolutions per second.

Bernstein, with the aid of a contact break somewhat different from that used by Blaserna, also examined the duration of the oscillations set up in a secondary coil. He found that the duration of the first oscillation at breaking primary was longer than that of the subsequent ones. The mean duration when using a single Grove cell in the primary circuit was ·0005 second, and when using a Daniell cell only ·0001 second. We shall return later to consider more recent researches on these electrical oscillations.

(To be continued.)

LIGHTNING CONDUCTORS.—VII.

BY DR. OLIVER LODGE.

(Continued from page 189.)

Record of Further Experiments, August, 1888.

41. A circuit was now prepared, of which every detail could be easily determined, and whose self-induction could be varied within certain limits at pleasure. The main part of it consisted of two wires stretched parallel to one another, about four inches apart, being supported at their ends by silk threads and glass pillars. To the ends of these parallel wires, and as prolongations of them, were arranged two very small Leyden jars, such as are supplied with an ordinary Voss machine, clipped in a couple of retort stands standing on a wooden table. From the outer coats of these jars, thus woodenly connected, two short wires led straight to the spark micrometer.

Connection with the machine was effected through wooden sticks, so that the machine and leading wires are quite out of the circuit as far as discharges and oscillations are concerned.

It was proved experimentally that none of the circuit beyond the wooden semi-interruption made the least difference. Nor did it matter whereabouts the wood made connection with the jar circuit. An A spark was provided by the universal discharger, which was placed under the two long wires so as nearly to bridge across the gap. This discharger could be shifted along the whole length of the wires,

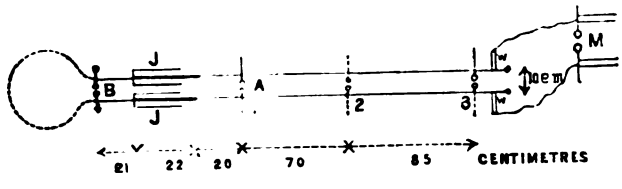

FIG. 9.

J are the two Voss jars arranged as shown in Figure, with long wire continuations, two No. 17 copper wires a decimetre apart. M is the machine and W are wooden connectors. A is the universal discharger, which can be placed in either one of three positions, 1, 2, 3. B is the spark micrometer, with an alternative path completing the circuit shown by a dotted line. Linear dimensions are expressed in centimetres.

and thus the self-induction of the jar circuit varied. Ordinarily three definite positions were employed, one near each end and one near the middle, labelled respectively 1, 2, and 3, as shown in the diagram. The knobs of the discharger and of the spark micrometer are the same as have already been described and experimented on, as recorded in § 21. The dimensions of the whole arrangement are best represented in the diagram.

It is necessary to specify the thickness of the different parts of the circuit:—

Thickness of No. 17 wires	·15	centim.
Thickness of rods inside jars	·98	,,
Thickness of A discharger rods	·60	,,
Thickness of B discharger rods	·58	,,

Capacity and Self-Induction.

The capacity of the two Voss jars in series, and of the two No. 17 wires, amounted altogether to 143 centimetres electrostatic units. This, therefore, is the value of S when the Voss jars are used.

Applying calculation to the rectangular circuit included between the A and the B knobs I make out that its self-induction in electromagnetic measure is as follows:—

For the A knobs in No. 1 position...	$L_1 = 1290$	centimetres.
,, ,, No. 2 ,, ...	$L_2 = 2677$	,,
,, ,, No. 3 ,, ...	$L_3 = 4397$	,,

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Alternative Paths.

42. A number of alternative paths were now prepared, all consisting of the same length of wire, namely, 235 centimetres, carefully bent into a circle about 2ft. 6in. in diameter, with ends arranged so as to be easily connected direct to the rods of the spark micrometer. They were all the same *length*, but of very different thickness and material, the finer wires being supported upon a hoop of cardboard.

The following table shows their thickness, their ordinarily measured resistance, and their calculated self-induction, for cases where the current keeps to their outer surface :—

Description of wire.	Thickness.	Resistance.	Self-induction L_0.
	Centimetre.	Ohm.	Centimetres.
No. 5 copper	·535	·0048	2,340
No. 2 iron	·71	·0166	2,230
No. 2½ brass	·68	·0051	2,240
No. 18 iron	·11	·254	3,100
No. 18 copper	·12	·092	3,060
No. 24 brass	·05	·89	3,470
No. 25 iron	·045	2·03	3,520
No. 23 copper	·065	·29	3,340
No. 40 copper	·01	2·60	4,230
"Longer leads"	·15	1·95	100,000

Sometimes much longer leads were used, consisting of a pair of No. 17 copper wires, each 38·2 metres long, arranged along and across the room, parallel to one another, so as to enclose a distorted rectangle half a metre broad. Particulars of these are entered in the last line of the above table. The electrostatic capacity between one wire and the other was 147 centimetres.

43. A few rough preliminary experiments with these alternative paths were made to begin with, when it was noticed that the B spark was affected by the presence or absence of an opaque partition between it and the A spark, and not only an opaque partition—even a glass plate made a decided difference. The B spark was longer when the light from the A spark was suffered to fall upon it, and shorter when it was screened. This is manifestly the same effect as had been previously discovered by Dr. Hertz in the course of his experiments with an induction coil. He showed that it was ultra-violet light that was most effective in helping the passage of a spark, and hence the action of the glass screen.

The experiment is interesting now as proving that the A spark occurs infinitesimally before the B spark; sufficiently before it for light to have time to travel the interval between the two, though not necessarily any more than this. A screen of black card was now arranged so as to screen off the B knobs from the light from A. The varying illumination of the day was not found to make any appreciable difference, so the window light was ignored.

44. A systematic set of experiments was now made. The A knobs were set permanently 1·35 centimetre apart, and the B knobs adjusted by their micrometer-screw until about half the sparks failed and half passed. Their distance apart was then read, and the discharger A shifted to a fresh position (1, 2, or 3 in the above diagram), always keeping the A spark-length 1·35. Then B was adjusted again, and so on. The following is a record of the readings :—

Alternative path.	Length of B spark for different positions of A.		
	Position 1.	Position 2.	Position 3.
None	·638	·638	·638
No. 5 copper	·288	·210	·148
No. 2 iron	·271	·163	·090
No. 2½ brass	·269	·170	·105
No. 18 iron	·290	·120	·056
No. 18 copper	·310	·148	·148
No. 40 copper	·300	·275	·173
No. 24 brass	·260	·200	·128
No. 25 iron	·275	·068	·078
No. 23 copper	·291	·245	·175
"Longer leads"	·338	·183	·183
None	·525	—	·523

The iron conductors gave the sharpest and most definite value for the B spark-length, and the coppers gave the least definite value of all the alternative paths. When no alternative path was used the critical spark-length was much more vague, considerable variation being possible before the B sparks either wholly failed or always passed.

45. Next day the retort holders were removed from the jars so as to get rid of a possible effect of their capacity, and the jars were mounted on paraffin blocks instead; but when no alternative path was used their outer coatings were connected imperfectly by a wooden penholder or something of the sort laid across them.

The B interval was now usually adjusted until the sparks there were just ceasing, instead of being half-and-half. The same Voss jars were used, and A was still 1·35 centimetre. The following table shows the result :—

Alternative path.	Critical length of B spark for different positions of A.	
	Position 1.	Position 3.
None	·800	·745
No. 25 iron	·330	·100
No. 5 copper	·345	·100
No. 2 iron	·323	·118
No. 25 iron	—	·173 Unilluminated.
„ „	—	·293 With magnesium burning close to.
„ „	—	·275 Not screened from view of A spark.
„ „	—	·243 Screened off again.
Longer leads	·550	·323
Longer leads with far ends disconnected	·400	·300
Longer leads with ends joined again	·563	—
Ditto	·580	Sparks just ceasing.
Ditto	·450	Sparks about half-and-half.
Ditto	·240	Sparks never failing.
None	·800	Sparks just ceasing.

The discharger A was then removed from any of its three regular positions, and put right away at the end of the "longer leads." In this case an A spark 1·35 centimetre long could not be obtained, by reason of leakage; so it was shortened to ·97, and the following readings taken. The B spark was now relatively enormous when there was no alternative path, although A had been so much shortened.

Alternative path.	Critical B spark, with A at far end of leads.
No. 25 iron	·040
No. 5 copper	·031
None	1·620
No 2 iron	·028

As a variation the A discharger was restored to its old position, A_1, and the B knobs put right away at the end of the longer lead. The A spark being still ·97, the following readings were taken :—

Alternative path.	Length of B spark at far end of leads.	
	A in Position 1.	A in Position 3.
None	·271	·430
No. 25 iron	·069	·054

It must be noted that the here used A spark lengths, 1·35 and ·97 centimetres, become, when reduced to flat plates, 1·1 and ·85 respectively.

(To be continued.)

REVIEWS.

La Telegraphie Actuelle. By L. Montillot. (Baillière et Fils Paris, 1888.)

In this work of 330 pages and 131 cuts the author makes a bold and not altogether unsuccessful effort to give a clear, if in parts condensed, description of the telegraph lines, system of working, and instruments in use in France, together with some

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brief reference to apparatus invented and used in other countries.

M. Montillot is connected with the Department of Military Telegraphs, and is at the same time professor at the Saumur Cavalry School, and his book is in parts a *résumé*, and in parts an extension, of lectures delivered in these capacities. It is written in such a style that "he who runs may read," and, what is more, understand the general outline of the telegraphic and telephonic applications of electricity, and is, therefore, specially suited for that general public which, not having time or opportunity of going very deeply into the study of electricity, is yet interested sufficiently to wish to know something of the means by which such results as it is familiar with are obtained.

In Chapter I. we are told how an aerial line is constructed, and a good description is given of Dr. Boucherie's process for injecting poles with sulphate of copper. This is the only "authorised" system in France, and has been found to give better results than treating them with chloride of zinc, creosote, linseed oil, tar, or by partial carbonisation.

Various forms of insulators are mentioned, but there is no reference to Johnson and Phillips's, or other forms of the "fluid insulator," which have given such excellent results in this country, on the Italian coast-lines, and elsewhere, but which are apparently officially unknown to the French administration. Several pages are devoted to an explanation of the *modus operandi* followed in France, Germany, Belgium, and England for laying underground lines, and brief reference is made to submarine cables, and to the bridge, loop, and Lumsden fault tests. In following chapters we find descriptions of various forms of voltaic cells, the Wheatstone bridge, resistances and condensers. Breguet's alphabetical instruments, and various types of Morse recorders, are fairly explained, and instructions given for setting them up.

No less than fifty pages are devoted to a comprehensive description of the Hughes type-writer, from its origin, through successive developments, to its present form. Twenty pages are given to the Wheatstone, and we then, after brief mention of the Meyer instrument, come to the most remarkable achievement of French telegraphy, the Baudot, which was the natural sequence of the Meyer, and which, in France, has quite supplanted its predecessor.

These instruments are but little known outside a limited circle in England, and a few words about the first of them may not be out of place, though anything like a full description of either would not be practicable within the limits of the present notice.

M. Meyer's invention is based upon the fact that in Morse transmission, owing to the necessity for spaces separating the different signals of the same letter, between letters, and between words, rather more than fifty per cent. of the time occupied in signalling is lost, and he tried to devise a means whereby this lost "space time" could be utilised for the transmission of a different set of signals. In the simplest form of M. Meyer's apparatus there are four keys, four receivers, and a distributor or current divider at each end of the line. The receivers and the divider are governed by the same clockwork movement, and synchronism is maintained between them and the corresponding instruments at the distant end of the line.

The key is formed of eight contacts, putting the battery in communication with the divider, which is an ebonite disc, each quarter section of which is formed of four sets of three contacts, two of which are by means of a revolving switch put in momentary connection with the line, while the third gives a passing discharge to earth. By means of the key any letter of the Morse alphabet can be formed in advance, stored up on the divider, and carried on to the line at the moment the switch passes over the contacts. The line is by means of the third contact put to earth between each signal. Supposing that all the four keys are used, the signals made from them on to the divider are taken up in succession by the revolving switch, passed over the line, and at the distant end a second divider distributes them to the receiving instruments.

A thorough description of the Meyer system will be found in the *Zeitschrift für Elektrotechnik*, 1885, with numerous cuts, illustrating the mechanical details of this ingenious invention.

M. Baudot, starting with the idea of reproducing in type the Morse signals received by the Meyer, was led step by step to the production of the beautiful, though complex instrument which, first exhibited at the Paris Exhibition of 1878, has since come into use on most of the busy circuits in France, and is likely to become the favoured multiplex system over the greater part of the European Continent.

M. Montillot, after giving over thirty pages to a description of the Baudot, winds up by saying, "In so limited a space we have been unable to enter into the minor details of so complicated an apparatus as the Baudot. There remains much to be said of the means used for regulating or modifying the movements of the different parts of the instruments, and for enabling them to work under the ever-varying conditions of long lines. . . . Nothing can replace the instrument itself for those who wish really to thoroughly master all its details; and for such a careful and thorough dissection of it alone will enable them to obtain a perfect comprehension of all its parts." We venture to think, however, that a very fair idea may be obtained from M. Montillot's work. A good description of both Meyer and Baudot's invention will also be found in "Les Télégraphes," by the late M. Ternant, published by Hachette and Co., Paris.

In Chapter VII., astatic, marine, and ordinary signalling mirror galvanometers are described, together with Sir W. Thomson's recorder. The woodcut illustrating this latter is faulty in several parts, and it seems strange to find the instrument itself spoken of indifferently as a "recorder" and a "siphon."

Estienne's modification of the Morse is favourably noticed, and as a successful experiment of it is stated to have been made upon the Brest-St. Pierre cable, it is likely we shall hear more of it before long.

The various duplex arrangements of Messrs. Stearn, Orduna, Brasseur, and De Sussex receive due mention. We are somewhat astonished to find no description of Muirhead's or Ailhaud's, at any rate by name, although what M. Montillot terms "duplex by differential coil," and illustrates as applied to a Morse line, may be the latter under a modest incognito.

The two concluding chapters are devoted to summary descriptions of the various forms of telephones most in use in France, and Van Rysselberghe's arrangement for the simultaneous use of the same line for telephonic and telegraphic purposes.

That he may remain true to the title of his book, M. Montillot closes it by reference to Mr. Ader's newest idea on the subject of working submarine cables by telephones which was described and illustrated in *The Electrician* of March 30, 1888, p. 569. M. Montillot says:—"We have already stated that all attempts to work cables by means of telephones had failed, owing to the retardation, and to the fact that the propagation of the current through these long lines was effected in a manner exactly the reverse of that required for telephonic vibrations. To obtain any result, then, it became necessary to resort to artifice. Mr. Ader proposes to obtain audible signals by means of telephones, using positive and negative currents, exactly in the same manner as is now done for the mirror or recorder. At the receiving end of the cable the line is forked, and joined to two make-and-break coils, giving by their vibrations sounds which can be easily made distinguishable one from the other. The other ends of these coils are joined to two telephones connected, one to the positive the other to the negative poles of a battery, the middle of which is to earth. It follows that the current coming *from* the line flows through the two make-and-break coils, the two telephones and both sides of the battery before finding an earth. But whatever be the line current, it meets in one of the branches of the receiving circuit a current of the same name, and in the other branch an opposing current; there is consequently in one branch a strengthening of the arrival current, and in the other a weakening of it, so that in one telephone is heard a strong tick, in the other a weak one, and this latter can by suitable adjustment be almost entirely suppressed. If a positive current produces a strong sound in the right hand (or ear) telephone, a negative current will act similarly on the left-hand one; in short, the currents are thrown on to the line at the home end as if intended to be read off on a recorder. At the distant end they are halved by the vibrators, strengthened on one side of the local battery, and weakened on the other. The telephones being

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specially regulated to respond one to the positive the other to the negative currents, sound reading becomes perfectly easy. We are unaware if this new plan has been practically applied; but it would seem to have a great future before it, if it were completed by a simple system enabling the transmissions to be controlled and checked."

"La Télégraphie Actuelle" will be found a useful little book by English students desirous to familiarise themselves with the French methods of working, and at the same time to learn some of the technical expressions with which they should be familiar before attempting the study of more advanced books.

Puck's Girdle. Edited by C. ARMSTRONG. (London: Wyman and Sons.)

Under the title of "Puck's Girdle," Mr. C. Armstrong, of the Edinburgh post office, has gathered together some "Gleanings from the Postal and Telegraph World" in the form of a shilling Christmas annual, the contents of which ought to prove attractive to readers outside that particular world, as well as inside.

Calendar for Electricians, 1889. By F. UPPENBORN. *(Kalender für Elektrotechnikes,* 1889.) (R. Oldenbourg, München und Leipzig.)

We have received from the publisher the 1889 issue of the above, already in its sixth year. As it is pretty widely known, it is hardly necessary to say it aims at being a sort of annual Munro and Jamieson. Some of the matter would perhaps be more in place in a text-book, and might with advantage be left out in a publication which should be as small as possible, consistent with fulness. The legitimate pocket-book matter, however, is generally complete and well chosen.

A Workman's Electric Lighting Vade Mecum. By S. v. GAISBERG. *(Tascenbach für Monteure Elektrische Beleuchtungs Anlagen.)* (R. Oldenbourg, München und Leipzig.)

This practical little work, now in its third edition, is apparently written by a man who has himself had to teach workmen. In plain and simple language, it contains good sound information, and is just the book which, if put into the hands of an intelligent man in charge of an installation, should make him capable both of keeping everything ship-shape, and putting right anything which goes wrong. It should also be valuable to the mechanical engineer, when, as frequently happens, he has an installation in his factory without skilled electricians on his staff.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION II.—ELECTRO-MAGNETIC FIELDS.

(Continued from page 193.)

141. *Kapp Lines.*—At this stage it may be well to allude to the English unit of magnetic induction introduced by Mr. Gisbert Kapp, and now largely in use by manufacturers of electrical machinery. A new unit line of force, equal to 6,000 C.-G.-S. lines, is adopted, and the sectional area of iron is taken in square inches instead of square centimetres. The new unit of induction is therefore one of these assumed lines per square inch section, and is generally known as one Kapp line per square inch, or one English unit of induction.

The number 6,000 is composed of two factors, viz., 60, which enables the formula for the E.M.F. produced in a rotating armature to be expressed in revolutions per minute instead of per second; and the factor 100, which brings the measurement of induction down to figures in the tens instead of thousands. Now, if we divide 6,000 by 6·4514 (the number of square centimetres in one square inch), we have the number of C.-G.-S. lines per square centimetre equivalent to one Kapp line per square inch = 930·03, or say 930; therefore,

1 Kapp line per sq. in. = 930 C.-G.-S. lines per sq. cm.,

or 1 English unit = 930 C.-G.-S. units of magnetic induction.

For the purpose of comparison the vertical ordinates of the last curve have been reduced to Kapp units by dividing the values of **B** by 930 (Fig. 123). The highest induction arrived at in this specimen of soft iron is seen to be 18 lines, and the practical saturation 17·2 lines (16,000 C.-G.-S. lines). In the previous paragraph we noted that there was no absolute limit to induction, and that 20,000 C.-G.-S. units (= 21·5 Kapp units) might be considered a fair average induction in machines whose armatures were of well-annealed wrought iron. The extremely high value reached by Prof. Ewing of 45,350 C.-G.-S. lines with wrought iron is equivalent to 48·7 Kapp lines. One or two examples quoted from descriptions of dynamos in which the induction is expressed in these units may render their practical application intelligible. For instance, in *The Electrician*, Vol. XX., page 35, we find:—

"The cross-sectional area of the magnet bars is 30 square inches, and the total cross-sectional area of actual iron in the armature is 20 square inches. The total excitation of field-magnets at full load is 12,130 ampere-turns, and the total strength of useful field is 378 lines (English measure). The density in the magnet cores is therefore 12·6 lines per square inch, and in the armature core 18·9 lines per square inch."

Again, on page 162, in the description of another machine: "The field strength in the core, according to the figures supplied us, works out at a very high figure, viz., to 23·6 lines per square inch." These calculations are on the basis of Mr. Kapp's formulæ given in his Paper on "The Predetermination of the Characteristics of Dynamos" (*Journal* Soc. Tel. Eng., No. 64), and take into account magnetic resistance and leakage. In that Paper Mr. Kapp gives the average

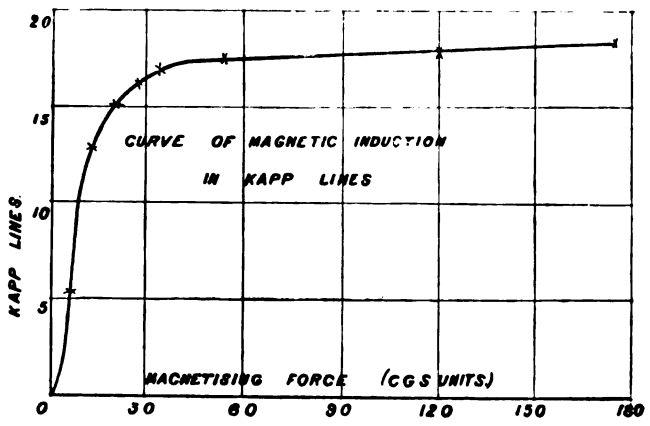

FIG. 123.

practical saturation values of induction derived from numerous data and experiments on machines, pointing out that the figures given are by no means the highest obtainable with exceptionably good iron. These are as follows:—Armatures built of well-annealed charcoal iron wire 25 lines per square inch, armatures built of discs of the same iron 22 lines, field-magnets of hammered scrap iron 18 lines. Multiplying by 930 we find these are equivalent to 23,250, 20,460, and 16,740 C.-G.-S. lines of induction respectively. Considerable exception to these English units was taken by scientists at the time of their introduction two years ago, chiefly on the ground of the necessary transposition of coefficients used with formulæ based on the inch-minute system into their value on the centimetre-second system. Mr. Kapp's reply to this and other objections (Society of Telegraph-Engineers' meeting, Dec. 2nd, 1886), was as follows:—"I use minutes because everybody is accustomed to counting revolutions per minute, and anybody quite unacquainted with French measure can work my formulæ, and would at the same time see what he is doing. The figures are of reasonable magnitude, and present to those who use them a definite meaning. They know what is meant by 17 lines to the square inch, but if we talk of 15,800 to the square centimetre a greater mental effort is required to grasp the meaning. . . . The translation from it to C.-G.-S. units is really not such a difficult matter as we are told, and with a little training one could get to manage either system equally well; but we have to talk to our workmen, and then we could not use grammes, centimetres, and seconds. We must give them figures in the usual English measure, and therefore it saves labour if we make the calcula-

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tions in a system where the figures are of reasonable magnitude and directly applicable to the various purposes of the workshop."

142. *Magnetic Permeability.*—To denote the degree to which iron and other magnetic metals permit lines of magnetic induction to *permeate* through their substance, under the action of a given magnetising force, the term "*permeability*" has been applied. The permeability of a specimen of iron is said to be high if it will permit the flow of a large magnetic induction through its mass for the expenditure of a small magnetising

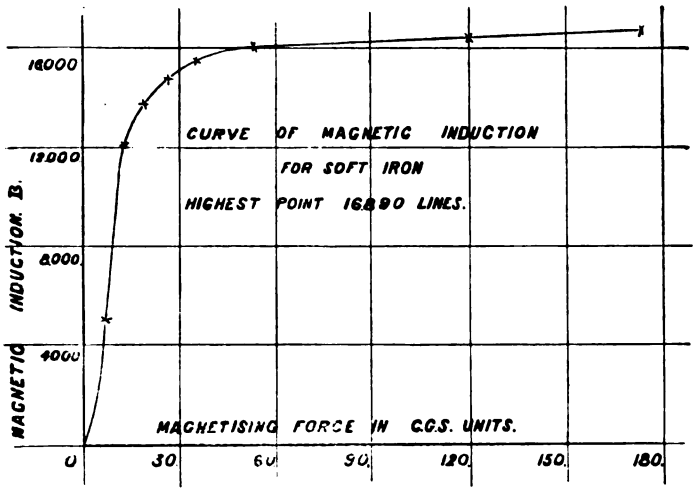

FIG. 122.

force, and *vice versâ*. In other words, magnetic permeability is the ratio between magnetic induction **B** and magnetising force **H**, and is usually denoted by the Greek letter μ. By inspection of the curves it will be seen that this property, like that of susceptibility, is not a constant quantity for any given kind of iron, but depends on its magnetic condition. For instance, in the curve given (Fig. 122) when the induction is between the limits of 4,000 and 12,000 C.-G.-S. lines, the permeability is fairly constant at about 800, but gradually falls to 300 at 16,000 lines, and ultimately to 100. In softer specimens of iron the permeability may reach 3,000 or 4,000.

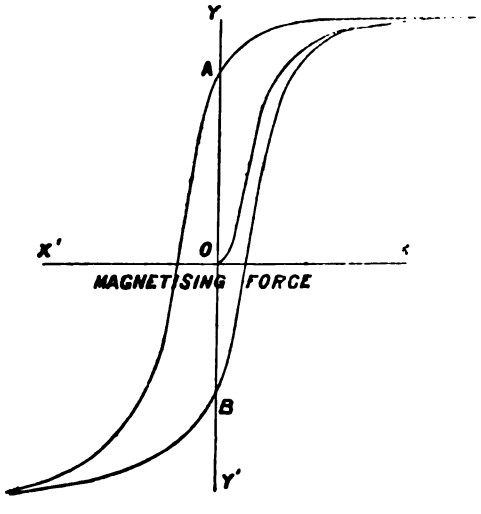

FIG. 120.

The meaning of these figures may be better appreciated by considering them as indicating the permeability of iron with reference to that of air. In a magnetising coil, with no iron present, the induction produced in the air space in the interior is identically the same as the magnetising field, and, therefore, the ratio of the two, *i.e*, the magnetic permeability of air, is equal to unity. The number indicating the permeability of iron is therefore the number of times its permeability exceeds that of air. When iron is acted upon by an alternating or increasing and diminishing magnetising force, its permeability, when not near saturation, is constant. The parallelism of the ascending and descending lines in the cyclic curve of magnetisation (Fig. 120) shows the susceptibility to be constant for low magnetising forces, and it follows that the permeability is constant. The exact relation between permeability and susceptibility may be found by taking the fundamental formula given in para. 139.

$$\mathbf{B} = 4\pi\mathbf{I} + \mathbf{H},$$

and dividing each side by **H**; we then have

$$\mu = 4\pi\kappa + 1,$$

or Permeability = 1 + Susceptibility × 12·57.

We may regard the term permeability as meaning the conductivity of iron to lines of force, in the same way as we speak of the conductivity of iron to the passage of electric currents; with this important difference, however, that while the electrical conductivity of iron at a given temperature remains constant for all intensities of current, its magnetic permeability decreases to a very marked extent as the intensity of magnetic-field or number of lines through it is increased.

If we pass an electric current through a piece of iron wire, and gradually increase the intensity of current until the wire is red-hot, the conductivity of the metal will have undergone a considerable change. As soon as the intensity of current is sufficient to cause the slightest rise in temperature of the iron, the conductivity of the latter commences to diminish, and beyond this point any increase in the flow of current causes a rapid diminution of the conductivity. This decrease of conductivity in an electrical circuit, on increasing the intensity of current through the conductor, may be taken as being somewhat analogous to the decrease of permeability in a magnetic circuit, on increasing the intensity of magnetic flow, or induction through the iron.

(To be continued.)

BOOKS, &c., RECEIVED.

"The Telephone." By W. H. PREECE, F.R.S., and JULIUS MAIER, Ph.D. (London: Whittaker and Co.) (The Specialists' Series).

"*Journal* of the Society of Telegraph-Engineers and Electricians. Vol. XVII. No. 75. (London: E. and F. N. Spon.)

"The Electric Motor and its Applications." By T. C. MARTIN and J. WETZLER. Second Edition, Enlarged. (New York: W. J. Johnston.)

"Price List of Incandescent Lamps and Holders." The Edison-Swan United Electric Light Company.

"The Modern Service of Commercial and Railway Telegraphy." By J. P. ABERNETHY. (Cleveland, Ohio.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

SATURDAY, January 5th.

ROYAL INSTITUTION.

3 p.m. Juvenile Lecture, "Clouds and Cloudland." By Prof. DEWAR.

TUESDAY, January 8th.

ROYAL INSTITUTION.

3 p.m. Juvenile Lecture, "Clouds and Cloudland." By Prof DEWAR.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be read, "The Compound Principle applied to Locomotives." By EDGAR WORTHINGTON, B.Sc., Assoc. M. Inst. C.E. At this meeting the monthly ballot for members will be taken.

WEDNESDAY, January 9th.

SOCIETY OF ARTS.

7 p.m. Juvenile Lecture II., "How Chemists Work—an example to Boys and Girls." By Prof. HENRY E. ARMSTRONG, Ph.D., F.R.S.

THURSDAY, January 10th.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Inaugural Address by the President, Sir WILLIAM THOMSON, F.R.S.

FRIDAY, January 11th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read, "Refrigeration and the Artificial Production of Cold." By G. A. BECKS Stud. Inst. C.E

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
	s. d.	s. d.	s. d.
For Foreign Parts and Colonies:—			
Within Postal Union	6 6	12 6	24 0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

TO ADVERTISERS.

"The Electrician" offers exceptional advantages to Advertisers. **It has the largest circulation of any English Electrical paper, and circulates all over the World.**

Particulars relating to Advertisements will be promptly forwarded on application to this office.

Trade Advertisements *intended for the current issue must be handed in not later than First Post on Thursday morning.*

Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

TECHNICAL PRINTING.

"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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Royal 8vo. Cloth Boards, 3s. 6d., post free 4s. (Great Britain).

Early in each year is issued "The Electrician" Electrical Trades' Directory and Handbook. *The Directory was established in 1883, and has now attained considerable proportions. Every care is taken to make the names and addresses of all persons engaged in the Electrical Industries absolutely accurate. Useful Tables and Electrical Formulæ are given, together with popularly-written Biographical Notices of the leading Electricians, accompanied in many cases by Portraits.*

THE DIRECTORY for 1889 will SHORTLY BE READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 239
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 244
Lightning Conductors.—VII. By Dr. Oliver Lodge. Illustrated. Continued 245
Reviews 246
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 248
Meetings of Scientific Societies. 249
1888 250
Summary of Electrical Events for 1888 253
The Central Lighting Stations of the United Kingdom 255
The Board of Trade and the Lighting of London 256
Dynamo Regulation by means of a Third Brush. By Edward Caldwell, A.B., M.E. Illustrated. Concluded 256
American Notes 258
Notes from Paris 259
Notes from Brussels 259
Correspondence—
Electrical Dissipation of Fog. Oliver J. Lodge 260
Electro-Magnetic Shunts.—W. H. Preece 260
Flashed Filaments in Lamps. Silvanus P. Thompson 261
Electrical Defence.—E. L. Zalinski 261
Blondlot and Curie's Electrometer.—L. B. Atkinson 261
Electric Traction.—T. Parker and Radcliffe Ward 262
Battery Transformers and the Vienna Installation.—R. E. Crompton 262
Technical Education.—John Perry 263
Primary Batteries.—O. C. D. Ross 263
Alleged Piracy.—S. Sudworth 263
Glasgow City Hall Lighting. G. T. P. 263
Patent Record 263
Technical Education 264
The Eastern Telegraph Companies' Annual East-End Concert and Dinner 265

1888.

The historian of the future will probably date the introduction of electric lighting upon a grand scale from the year 1888, and from the passage of the Electric Lighting Amendment Act; and in commencing our review of the electrical events of the year this is naturally the one which first engages our attention. This important measure was introduced into the House of Lords by Lord Thurlow in March, and finally passed into law on 18th June. It is well known that the Act provides for an extension of the period before the compulsory purchase clause of the Act of 1882 becomes operative from twenty-one to forty-two years, and it also modifies the terms of purchase in favour of the contractors by the introduction of the phrase, "fair market value." What is the exact bearing and value of the last-named concession still remains to be discovered. The acceptance of this, or some very similar measure of relief, having long been regarded as a foregone conclusion, even at the commencement of the year many schemes were already afoot for the establishment of Central Lighting Stations and for the formation of Electricity Supply Companies, chiefly within the Metropolitan area. The passing of the Act was therefore immediately followed by an outburst of activity in this direction, and it is satisfactory to note that up to the present the movement has, upon the whole, proceeded upon perfectly sound and healthy lines. Whilst there has been no sign whatever of the inflation which characterised the imperfect schemes and preposterous financial ideas in vogue in 1882, yet there has been little or no difficulty in obtaining financial support for the majority of the undertakings now in progress. In more than one instance—including that of the largest scheme afloat—the whole of the capital has been raised by private subscription, and the public have not even been asked to contribute; in other cases a large proportion of the shares are held by leading companies, or firms of electrical engineers. This must certainly be considered a healthy and satisfactory feature.

On taking a general survey of the various projects in hand one cannot help being struck by the singular diversity of operations which they present. Out of the ten or a dozen

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stations in London now either in active existence or which are in a more or less advanced stage of progress, it is a remarkable fact that no one system can claim more than two examples at the most. But as we shall devote a separate article to a consideration of the development of electrical engineering during the year, we do not here intend to enter upon a technical description of these schemes; so that we shall confine ourselves to some general remarks upon the recent history of the movement and the present aspect of affairs. Excluding two small arc-lighting stations of the Pilsen-Joel Company and one Fyfe-Main station now being constructed at Brixton, the remainder of the London installations may be broadly divided into storage-battery and alternate-current transformer systems. Of the battery stations there are four in hand, exemplifying three different methods of utilisation. The Chelsea Supply Company, when its works are ready, will employ battery sub-stations provided with the ingenious automatic arrangements which have been worked out by the officers of the E.P.S. Company. The Cadogan Company utilises the highly interesting and remarkable distributor of Mr. H. Edmunds. These two are both high-tension "transformer" systems, whilst at Kensington Court and also at Whitehall we have genuine low-tension network systems, in which the batteries are confined to the engine-room, and are used only for storage purposes. So far as Kensington Court is concerned, it is probable that if the experience of Mr. Crompton at Vienna should prove sufficiently favourable, his method of battery sub-stations will be introduced at a later stage. The adoption of secondary batteries upon this extensive scale goes far to show that the storage cell, as adapted to electric lighting purposes, has now assumed a form which entitles it to some degree of confidence.

But interesting and hopeful as these schemes most certainly are, it is to alternate-current transformers that we must turn in order to observe the grandest and most striking features in the present development of electric light engineering. The Grosvenor Gallery station, with its 30,000 lamps, is a *fait accompli* which already takes rank with the most important even of American stations. The Bond-street station is, however, but a comparatively insignificant item in the vast scheme which the London Electric Supply Corporation is actively pushing forward. As soon as the gigantic designs of Mr. Ferranti have been realised, the monumental station at Deptford will supply a whole series of sub-stations—of which the Grosvenor Gallery will be one—with an alternating current at 10,000 volts potential, which will thence be distributed at a lower potential throughout an area which, if the hopes of the promoters are realised, will practically extend over the whole of London proper. At the end of December the building operations at the Deptford station are rapidly approaching completion; most of the boilers have been fixed, and the work of erecting the engines will shortly commence.

The Metropolitan Electric Lighting Company have likewise embarked upon an ambitious programme, but instead of placing their eggs all in one basket, they have decided to create a number of separate stations in various parts of Central London. The City is to be provided for by a station at the southern end of Southwark Bridge, a second station will be built on the same side of Waterloo Bridge, a third in Sardinia-street, near Lincoln's Inn-fields, and a fourth in Marylebone. Alternate-current transformer methods will be employed in every case, but up to the present time the only contract which has been settled is one with the Westinghouse Company for the Sardinia-street station. The Metropolitan Company has also taken over the Whitehall Mansions installation. The House-to-House Electric Light Supply Company has a station, now almost ready for work, at West Brompton, where the Lowrie-Hall alternate-current transformer, a system which has proved so successful at Eastbourne, is employed. This company, in common with most of the others which have been alluded to, has given notice to the local authorities of its intention to apply for Provisional Orders over a considerable portion of the Metropolitan area. A Mordey alternator plant is also at work in a small central station in Oxford-street, which is in private hands.

Turning to the provinces we do not find so much progress to record. In Liverpool, where Messrs. Holmes and Vaudrey have had a small central station at work for several years, two other stations in the hands of the same firm have been recently completed, and a total of 3,000 lamps is now supplied over an area which includes the chief business part of the town. All these belong to the low-tension direct-current class. The Bradford Corporation have contracted with Messrs. Siemens for the supply and erection of low-tension direct-current plant; and this is noteworthy as being the first instance of a Municipal Central Electric Lighting Station in this country. Here, however, the building operations are still incomplete. The Corporations of Dublin and of Swansea have applied for Provisional Orders to enable them to follow suit. The Leamington installation, which at first laboured under some difficulties, has now been running without any hitch during the whole twelve months, though the public are still dissatisfied with the street lighting. At Brighton the interesting and successful multiple-series system, which had been cleverly worked out by Mr. Arthur Wright, having arrived at a point where it did not lend itself to further extensions, is being replaced by an alternate-current system. At Bath Mr. Massingham has under weigh a contract to light the streets with Thomson-Houston arcs, power being derived from the waters of the Avon, whilst the Taunton station continues to do satisfactory work. At Barnet Mr. Joel has started an installation for street-lighting with Bernstein lamps, but owing apparently to an attempt to carry out the work in too short a time the result is not at present satisfactory. A small Ferranti station was started in Chatham in the middle of December. Adding some others of minor importance, the total number of central stations in actual operation in this country is now twenty-six, of which eight were opened during the past twelve months. There are also seventeen stations actually in process of construction and eleven others projected, including only those whose prospects of realisation seem reasonably assured.

One of the natural results of the extensive preparations for central station lighting has been, so far as London is concerned, to place some check upon the increase of isolated stations. But, notwithstanding this, the general demand for electric lighting plant and apparatus of all descriptions has undoubtedly been greater this year than at any previous period, and still continues to improve. Broadly speaking, it may be said that all the leading makers are now well employed. Overtime working and plans for the extension of works are reported in several directions. The improvement is specially felt by the manufacturers of insulated wire, switches and cut-outs, electroliers, &c., in which class a very extensive and profitable trade is now being done; in fact, for the makers of all these minor adjuncts the prospects are very good indeed.

The enforcement and interpretation of the Electric Lighting Acts having been entrusted to the Board of Trade, that body finds itself charged with a task of the most onerous and responsible character. One of the most important of its duties is the framing of rules and regulations for each undertaking, in order to safeguard the interest of the consumers as well as of the general public; but it has wisely decided not immediately to enforce any general code. Two questions of the first

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degree of importance in the administration of the Act remain at present in a state of some uncertainty. First, as to how far the application of the Act is compulsory where the Local Authority is willing to allow mains to be laid. This question has arisen at Ipswich, where Messrs. Paris and Scott are erecting a central station, and the Board in the early part of December expressed their inability to come to an immediate decision on the point. Secondly, in what degree does the possession of a Provisional Order confer a monopoly of the power of laying mains in the scheduled district? At the end of November this serious question assumed an acute form in Chelsea, where the opinion of the Vestry differs from that of the Chelsea Electricity Supply Company. The point is one of fundamental importance, but no decision has yet been arrived at. The Board of Trade has recently announced that it does not intend to issue any more "Licenses" for the Metropolitan area, so that further extensions will have to be by way of Provisional Order.

Coming now to the application of electricity to the transmission of energy, we cannot report much progress. Large numbers of electric motors have undoubtedly been sold during the year, but there is little of general interest to record. The utilisation of motors in connection with central station currents is still a thing of the future so far as this country is concerned. No new electric tramway has been started during the year, although several experimental cars have been running. Electric launches have appeared on the Thames on several occasions, and Messrs Immisch and Co. are understood to be building quite a number of boats of this description for next summer. It has been decided to work the City and Southwark Subway by electricity, but the contract has not yet been assigned. The directors of the Metropolitan Railway have also entered into negotiations with the Electric Traction Company in connection with the application of electricity to the underground lines—a consummation most devoutly to be wished! Some interesting and successful work has been done in connection with the use of electric motors in mines, principally by the firm of Immisch and Co. We are now looking forward to the introduction of alternate-current motors, which, if thoroughly successful, have undoubtedly a great future before them. The progress which has been made in this direction during the past twelve months has been of a highly remarkable character, and leaves little doubt of the ultimate solution of the problem—perhaps in more ways than one.

The attention of both scientific and practical men has been strongly drawn to the very important question of Lightning Conductors, and incidentally, therefore, to lightning. At this time last year we had scarcely realised how very shadowy is our real knowledge of these subjects. The superiority of copper over iron as the material for lightning conductors was understood to have been fully proved by the researches of Prof. Hughes, and it was not until Prof. Silvanus Thompson drew the attention of the Physical Society in January to the influence of the melting point of the metal that the slightest misgiving as to the soundness of this conclusion was entertained. In March, however, Dr. Oliver Lodge, whilst engaged in preparing for the delivery of the Dr. Mann lectures before the Society of Arts, made a discovery whose full significance can hardly as yet be realised. On offering a Leyden jar the alternative of effecting its discharge either across an air gap or by way of a closed metallic circuit, Dr. Lodge discovered that under certain circumstances a short and stout bar of copper presents a greater obstacle to the discharge than does a thin iron wire of much greater length. This singular and paradoxical fact has formed the starting-point of a series of remarkable investigations upon the nature of the static discharge, which has directed general attention to a long-neglected branch of electrical science, and bids fair to open up a wide field for discovery—and possibly, at a later stage, for invention. Amongst other conclusions at which Dr. Lodge speedily arrived is one of the highest interest and importance, namely, that the lightning flash may sometimes assume an oscillatory character, with a period of something like one-millionth of a second. In this way it is possible to account for some at least of the vagaries of lightning, which are otherwise wholly inexplicable. But the recognition of the oscillatory discharge—first discovered by Hehnholtz in 1847, and the theorem of which was extended by Sir William Thomson in 1855—offered no immediate explanation for the preference of iron over copper; in fact, it greatly increased the difficulty of the problem, and led, for a time, to the supposition that for very high rates of alternation the magnetic permeability (and hence the self-induction) of iron is vanishingly small. Later theoretical developments have, however, enabled Dr. Lodge to show that these assumptions are not only unnecessary, but that they are actually contradicted by experiment; and to the further elucidation of this question he is devoting the remarkable Papers which are now appearing in this journal. Dr. Lodge's views have been loudly challenged by the "practical" school, who were ably led to the attack by Mr. W. H. Preece during the Bath meeting of the British Association. The discussion cannot be said to have led to any very definite result, and since that date some of the most important advances in the general theory have been made.

In the spring of the year it was suggested by Messrs. Wheatley Kirk, Price and Goulty that a way out of the difficulties which surrounded the projects which had so long been under consideration for the establishment of some kind of electrical trades association might be found by the formation of a branch or section of the London Chamber of Commerce. This happy inspiration was taken up by the leading London firms, and after one or two preliminary meetings had been held the Electrical Trades Section of the London Chamber of Commerce became an established fact. The first meeting was held on Monday, 22nd October, when a committee of thirty-three members was elected by ballot, which committee subsequently elected Mr. R. E. Crompton as their chairman, with the Earl of Crawford and Major Flood-Page as vice-chairmen. The section, which now numbers some 200 members, is divided into the following sub-sections: Telegraph Companies, Electrical Manufacturers and Contractors, Telephone Companies, Electricity Supply Companies, Consulting Electrical Engineers, General, each of which has its own special representatives on the committee. The benefit of working under the ægis of the Chamber of Commerce is already manifest, and the valuable and efficient services of Mr Kenrick Murray, the general secretary of the Chamber, is fully appreciated. Several meetings of the Sectional Committee and Sub-Committees have been held, when the affairs of the Electric Supply Companies have been the chief topics of discussion. The organisation has so far worked with admirable smoothness, and we think it will prove capable of rendering valuable service.

Under the Presidency of Mr. E. Graves the Society of Telegraph-Engineers and Electricians has completed the most active—and, perhaps, upon the whole, the most successful—year of its existence. The Society has received a larger accession of members, has held a greater number of meetings, and the average attendance has been more numerous than in any previous session. In the month of April the Council issued a set of Installation Rules, a step the propriety of which was hotly contested on the part of the representatives of some of the Fire Insurance Companies. So far, however, the appearance of these rules can scarcely be said to have led

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to any practical result. The relative merits of the alternate current and the battery methods of distributing electricity have formed the principal subject of discussion during the Session, but the valuable Paper of Prof. Rücker on "Electrical Stress," and that of Prof. S. P. Thompson on "Influence Machines," have served to show that the Society does not altogether neglect the study of pure science. By an almost unanimous vote the title of the Society has now been changed to that of the Institution of Electrical Engineers.

Amongst the leading events of the year we have also to notice some topics of a less pleasant character—we refer to the costly and unhappy litigation in which several of the leading companies are involved. The action brought by the Edison-Swan Company against "Holland and Others" (*videlicet* the Anglo-American Brush Corporation) came before Mr. Justice Kay on April 17th, and occupied the attention of the Court for no less than twenty-two days. In this case it was sought to establish the exclusive right to manufacture incandescent lamps on the part of the holders of Mr. Edison's patent of November, 1879, and a subordinate claim for a monopoly of the "flashing" process was also entered for the Cheesborough patent. On 16th July Mr. Justice Kay delivered judgment in favour of the defendants in respect of the former claim, and in favour of the plaintiffs as regards the latter. An appeal was immediately entered by the Edison-Swan Company, and this came before the Court on December 1st. The argument lasted ten days, and the Court then reserved judgment, which has yet to be delivered.

On 29th June an action came before Mr. Justice Kekewich, in which Mr. Ferranti appeared as a petitioner for the annulment of the patent held by Messrs. Gaulard and Gibbs on the ground of anticipation and non-utility. After a hearing extending over eight days judgment was delivered declaring the patent null and void. An appeal was entered, which will come before the Courts in January.

A similar action for the voidance of a patent has been brought in the Scotch courts by Messrs. King, Brown and Co., of Edinburgh, who seek to demolish the claim of the Anglo-American Brush Corporation to a monopoly of compound winding; the ground chiefly relied on is an alleged anticipation by Mr. C. Varley. The case commenced on Nov. 27th, and has not yet been concluded.

(To be continued.)

SUMMARY OF ELECTRICAL EVENTS FOR 1888.

JANUARY.

Presidential Address of Mr. Edward Graves to the Society of Telegraph-Engineers.
The Metropolitan Board of Works resolve to permit Mr. W. Webster, jun., to carry out his electrical purification of sewage experiments at his own expense at Crossness.
Sir John Pender made a K.C.M.G.
M. Raynaud, Director of the Paris Telegraph School, assassinated.
New York Special Commission report in favour of death by electricity.
Launch of the Eastern Telegraph Company's steamer, "Amber" (19th).
Opening of the New York Electric Club.
The Volta Prize awarded to M. Gramme.
Trial of the Lineff and Jones Electrical Tramway at Chiswick (25th).

FEBRUARY.

Mr. Gisbert Kapp's Paper "On Alternate-Current Transformers" read before the Society of Telegraph-Engineers (9th).
Lighting of the Great Northern Railway Company's trains by electricity.
Mr. Raikes informed the House of Commons that the Government did not intend to renew the concession of the Submarine Telegraph Company (18th).
Meeting of the Association of Edison Companies at Chicago.
Meeting of the National Electric Light Association at Pittsburg.
The House-to-House Electric Light Supply Company registered.

MARCH.

Registration of the Gülcher (New) Electric Light and Power Company.
Second Reading of the Electric Lighting Act (1882) Amendment Bill in the House of Lords (5th).
Mr. Raikes informed the House of Commons that the Government contemplated no scheme for purchasing the telephones (6th).
The proposed contract with the Anglo-American Brush Corporation for lighting the City finally rejected.
Large contract of the Anglo-American Brush Corporation with the Australasian Brush Electric Light, Power, and Storage Company to light the Melbourne Exhibition; 800 arc and 3,000 incandescent lamps.
Dr. Oliver Lodge delivered his lectures on "The Protection of Buildings from Lightning" before the Society of Arts.
Death of M. Richard, the eminent French telegraph engineer.
Completion of the Vevey-Montreux Electric Tramway.
Decision of the Supreme Court of the United States, upholding the validity of the Bell Telephone Patent.
Committee of Investigation appointed by the shareholders of the Pilsen-Joel Company (13th).
Washington Capitol struck by lightning.
Paper on "Electrical Stress" read before the Society of Telegraph-Engineers by Prof. Rücker and Mr. C. V. Boys (22nd).
Meeting of the Maxim-Weston Company; a committee of five appointed to inquire into the affairs of the company (28th).
The use of gas in the Madrid theatres prohibited, and the adoption of the electric light within six months made compulsory (31st).

APRIL.

Paper read by Mr. J. W. Howell, at a meeting of the American Institute of Electrical Engineers, on "The Maximum Efficiency of Incandescent Lamps."
The Belgian Society of Electricians offer a prize of 250 francs for the best essay on the elementary principles of electricity.
Adoption of the Electric Lighting Scheme by the Gas Committee of the Bradford Corporation.
A Central Laboratory of Electricity inaugurated at Grenelle.
Report of the Pilsen-Joel Company Committee of Investigation (12th).
Issue of the revised Fire Rules of the Society of Telegraph-Engineers.
Paper on "Central Station Lighting, Transformers *v.* Accumulators," read before the Society of Telegraph-Engineers by Mr. R. E. Crompton.
The action brought by the Edison-Swan Company against the Anglo-American Brush Corporation came before Mr. Justice Kay (17th).
The New York Assembly passes a Bill in favour of Capital Punishment by Electricity, by 87 to 8 votes.
Lord Crawford's Electric Lighting Bill read a second time in the House of Lords (17th).
Death of Mr. T. R. Crampton, M.I.C.E. (19th).
Dinner to Sir John Pender, K.C.M.G. (23rd).
Telephone Union (Limited) registered (23rd).
Report of the Maxim-Weston Company Committee of Investigation (25th).
United Kingdom Telephone Union (Limited) registered on the (28th) with a capital of £10,000,000.

MAY.

International Convention for the Protection of Submarine Cables came into force (1st).
Completion of the largest arc light (6,000,000 candle-power) in the world at the St. Catherine's Lighthouse, Isle of Wight.
Death of Sir Charles Bright (3rd).
Lord Thurlow's Bill read a second time in the House of Commons (8th).
Opening of the Glasgow Exhibition.
Republication of the Paris Municipal Tariff.
The first words spoken over the Paris-Marseilles telephone line (562½ miles) (14th).
The Barnet Local Board conclude a contract with Mr. H. F. Joel for the lighting of their town by electricity.
The Bath Town Council resolve to advertise for tenders for electric lighting (22nd).
Paper on "The Influence Machine from 1788 to 1888" read by Prof. Silvanus P. Thompson before the Society of Telegraph-Engineers (31st).
Local Government Board Inquiry into the Bradford Electric Lighting Scheme.

JUNE.

Visit of the Cheltenham Town Council to the Eastbourne Central Station.
Amalgamation of the Edison Continental Company with the Swan Company, so far as concerns the French lamp patents (8th).

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Lord Thurlow's Bill passed through Committee (11th).
Local Government Board authorise the Bradford Electric Lighting Scheme (12th).
Lord Thurlow's Bill read a third time in the House of Commons (14th), and the Commons' Amendments subsequently agreed to by the Lords (18th).
Deputation to the Postmaster-General in support of the United Telephone Company's Bill.
Opening of the Gaulard-Gibbs *v.* Ferranti case, before Mr. Justice Kekewich (29th).
Paper by Mr. F. J. Sprague "On the Solution of the Municipal Rapid Transit Problem" read before the American Institute of Electrical Engineers.
The Electrical Purification Company (Limited), registered (23rd), formed to acquire Mr. William Webster's patents relating to the Electrical Treatment of Sewage.

JULY.

The Electric Launch "Malden" at Henley Regatta.
Judgment given for the plaintiffs in the Ferranti *v.* Gaulard-Gibbs case (9th).
Meeting of the Members of the London Chamber of Commerce interested in the proposed Electrical Section (13th).
Judgment given in the Edison-Swan *v.* Anglo-American Brush Corporation action for the defendants as regards the Edison Patent, and for the plaintiffs as regards the Cheesebrough Patent (16th).
Nomination of the Organisation Committee of the International Congress of Electricians (16th).
Adoption of the Electric Light Scheme at Bath (24th); Mr. Massingham's proposals accepted.
The Organising Committee of the International Congress of Electricians elect an executive committee (24th).
The Hotel de Ville, Brussels, struck by lightning (26th).
Further meeting of the Members of the London Chamber of Commerce interested in the proposed Electrical Section (27th).
Death of Mr. Hiram Sibley.
Formation of the Metropolitan Electric Supply Company, with a capital of £500,000.
The Paris Municipal Council vote funds for the establishment of a Central Station at the Halles Centrales.
The firm of Crompton and Co. converted into a limited liability company.
The Corporation of Wellington, N.Z., accept the contract of the Gülcher Company to light that city by electricity.
Experiments by Mr. Harold P. Brown at Columbia College on the death-dealing properties of the electric current.
The Chelsea Electricity Supply and the Cadogan Electric Light Companies registered.

AUGUST.

Mr. Hugh Watt, M.P., resigns his post as Chairman of the Maxim-Weston Company.
The Thomson-Houston Automatic Current-Regulating Patent upheld in the States.
Meeting of the Edison Association at Nantasket Beach, near Boston.
Failure of the Westinghouse Company to sustain the Gaulard-Gibbs Patent in the States.
Purchase of the Tesla Motor Patents by the Westinghouse Company.
Issue of an order by the Turin authorities directing that no theatre be allowed to remain open after the 1st November unless lit by electricity.
Death of Prof. Edlund (10th).
Meeting of the American Association for the Advancement of Science at Cleveland (15th).
Death of Lord Alfred Paget, C.B. (25th).
Meeting of the National Electric Light Association in New York (29th, 30th, and 31st).

SEPTEMBER.

Cessation of the Atlantic Cable Rate War (1st).
Death of Prof. Clausius.
Third Annual Meeting of the Victorian Electric Telegraph Association at Melbourne.
Meeting of the National Telephone Exchange Association in New York (4th and 5th).
Meeting of the British Association at Bath (5th).
Opening of the Berlin-Breslau Telephone Line (11th).
Completion of the Electric Lighthouse at the Copenhagen Exhibition.
Opening of the Arc de Triomphe Porte-Maillot Electric Tramway Line in Paris (15th).
Launch of Electric Submarine Torpedo-boat "Gymnote" at Toulon (25th).
Threatened Strike amongst Paris Telegraphists.
The Society of Arts Motor Trials.
Formation of an Electrical Institute in New South Wales.
Report of the new Directors of the Maxim-Weston Company.

OCTOBER.

Experiments at Issy with an electric submarine torpedo boat driven by means of a Schanschieff Battery.
Extraordinary General Meeting of the Maxim-Weston Company (3rd); the late chairman to be proceeded against.
Unveiling of a Statue to Ampère at Lyons.
The Town Clerk of Swansea directed to apply to the Board of Trade for a Provisional Order to light the town by electricity.
Blenheim Palace lighted by electricity.
Death of M. Cabanellas.
Opening of the new Burg Theatre at Vienna (14th inst.); lit by over 5,000 incandescent lamps.
First meeting of the Electrical and Allied Trades Section of the London Chamber of Commerce (22nd inst.).
The Town Clerk of Dublin instructed to take the necessary steps for procuring a Provisional Order (22nd inst).
Visit of the Technical Press to the Deptford Central Lighting Station of the London Electric Supply Company (24th).
Foundation stone of the Bradford Station laid (26th).
Inaugural *conversazione* of the Institute of Medical Electricity (30th Oct.).
Important agreement between the Westinghouse, Sawyer-Man, and Consolidated Companies of the United States.

NOVEMBER.

Visit of Kensington Vestry to Eastbourne Central Station (5th).
Report of the Manchester Jubilee Exhibition issued; total number of arc lamps employed, 512; total number of incandescent lamps employed, 3,570.
Trial of the Julien Car at Birmingham (7th).
Publication of the Brussels Exhibition Awards.
Tenders for the lighting of the Halles Centrales (Paris) sent in.
Electricity Applied to Tanning at Nordköping, Sweden.
Society of Telegraph-Engineers and Electricians resolve to change the title to that of the Institution of Electrical Engineers (8th).
Large Contract given by the Metropolitan Electric Supply Company to the Westinghouse Company.
United States Supreme Court reverses decision of Lower Court, and holds that the Government can bring suit to invalidate the Bell Telephone Patent (12th).
Meeting of the Pacific Cable Conference (21st).
The Thomson-Houston Electric Company commence an Electric Railway, 14 miles long, at Topeka (Kansas).
The Directors of the Pilsen-Joel Company recommended to wind up the Company (23rd).
Death of M. Lucien Gaulard (26th).
The case of King, Brown and Co. *v.* The Anglo-American Brush Corporation came before Court of Session in Edinburgh (27th).
Trial of a 125 horse-power Daft electric locomotive on the New York Elevated Railways (27th).
Messrs. Siemens and Halske secure the contract for lighting the Vienna Houses of Parliament.

DECEMBER.

Rejection of the memorial of the Chelsea Electricity Supply Company by the Chelsea Vestry, which resolved to allow the Cadogan Company and the London Electric Supply Corporation to lay underground wires in the neighbourhood.
Swan-Edison *v.* Holland and others. Appeal against Mr. Justice Kay's judgment (1st).
Maxim-Weston Company. The shareholders agree to the voluntary winding up and reconstruction of the Company.
Publication of the Programme of the International Congress of Electricians.
Acceptance of Messrs. Nicholson and Jennings's tender for the lighting of Cowpen (5th).
The Dublin Corporation reject the vote for the preliminary expenses connected with the electric lighting scheme (5th).
Inauguration of the Ipswich Central Station, constructed by Messrs. Lawrence, Paris, and Scott.
Sir William Thomson elected President of the Society of Telegraph-Engineers for the year 1889 (13th).
Experiments at Mr. Edison's laboratory with regard to the effect of currents of electricity on animal organisms.
Bath Urban Sanitary Authority affix their seal to contract with Mr. Massingham for the lighting of certain streets by electricity.
Prolongation of the agreement with the Submarine Telegraph Company until March 31st, 1889.
Royal Assent given to Patents, Designs, and Trade Marks Bill (24th).
The Board of Trade decide not to issue any further licenses for the Metropolitan area.

UNITED RIVER PLATE TELEPHONE COMPANY.—The directors of this company have declared an interim dividend for the half-year ended 30th September last of 3 per cent. (being 3s. per share), free of income-tax, payable on and after the 15th inst.

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From the forthcoming 1889 Edition of "The Electrician" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK.

THE CENTRAL LIGHTING STATIONS OF THE UNITED KINGDOM.—LONDON.

IN OPERATION.

Station.	Name of Company.	System.
Grosvenor Gallery	London Electric Supply Corporation	Alternate Current Transformers (Ferranti)
Kensington Court	Kensington Court Co.	Secondary Batteries (Crompton)
Cadogan (Manor-street, Chelsea)	Cadogan Electric Light Co.	Secondary Battery Distribution (Edmunds)
West Brompton...	House-to-House Electric Supply Co.	Alternate Current Transformers (Lowrie-Hall)
Whitehall	Metropolitan Electric Supply Co.	Secondary Batteries
Lincoln's Inn-fields	Pilsen Co.	Pilsen Arc and Direct Current Incandescent
Stanhope-street...	Pilsen Co.	Pilsen Arc and Alternate Current Transformers (Clerc-Teague)
Oxford-street.....	G. E. Pritchett and Co.	Alternate Current Transformers (Mordey) and Brush Arc
Paddington	Great Western Railway Co.	Gordon

IN PROGRESS.

Station.	Name of Company.	System.
Brixton	Fyfe-Main Co.	Fyfe-Main System
Deptford.....	London Electric Supply Corporation	Alternate Current Transformers (Ferranti)
Chelsea.....	Chelsea Electricity Supply Co.	Secondary Battery Transformers (E.P.S.)
Knightsbridge	Kensington Court Co.	Secondary Battery Transformers (Crompton)
St. James.....	St. James and Pall Mall Elec. Light Co.	Low Tension
Sardinia-street ...	Metropolitan Electric Supply Co.	Alternate Current Transformers (Westinghouse)
*Waterloo	Metropolitan Electric Supply Co.	(Not Selected)
*Manchester-square	Metropolitan Electric Supply Co.	(Not Selected)
*Southwark Bridge	Metropolitan Electric Supply Co.	Alternate Current Transformers
*Notting Hill	Notting Hill Electric Light Co.	Secondary Battery Transformers
*City	Crompton and Co.	Secondary Battery Transformers (Crompton)
*Osnaburgh-street	Portland Electric Light Co.	Secondary Battery Distribution (Edmunds)

PROVINCES.

IN OPERATION.

Station.	Name of Company.	System.
Taunton.....	Taunton Electric Light Co.	Thomson-Houston
Liverpool (3).....	Liverpool Electric Supply Co.	Low Tension
Sheffield.....	Sheffield Electric Light and Power Co.	Thomson-Houston and Mordey Alternators
Brighton	Brighton Electric Light Co.	Brush Multiple Series and Mordey Alternators
Eastbourne	Eastbourne Electric Light Co.	Alter. Current Transform. (Lowrie-Hall)
Hastings	Hastings and St. Leonards Electric Light Co.	High Tension Direct Cur.; underground wires; Arc & Incan.
Cardiff	Anglo-American Brush	Brush
Barnet	Messrs. H. F. Joel and Co.	Incandescent Street Lighting
Leamington	Midland Electric Light and Power Co.	Low Tension
Blackpool	Corporation	Siemens' Arcs
Ipswich	Ipswich Light & Power Association	Continuous Current Transformers
St. Austell.....	St. Austell Electric Lt. Co. (J. E. Veale)	Low Tension
†Glasgow	Corporation	Low Tension
Waterford.....	Laing, Wharton and Down	Thomson-Houston
Bradford	Schmidt-Douglas Co.	Schmidt's Improved Arcs and Incandes.

IN PROGRESS.

Station.	Name of Company.	System.
Bradford	(Municipal)	Low Tension
Bradford	Mutual Electric Lighting Co.	Low Tension
Bath	H. G. Massingham	Thomson-Houston
*Edinburgh	Anglo-American Brush Corporation	Brush
*Edinburgh	Muir, Mavor and Coulson	Ferranti
Cowpen (Blyth) ...	Nicholson & Jennings	Arcs and Incan.
Okehampton	Henry Geen	Low Tension
Chatham	Chatham, Rochester and District Electric Light Co.	Ferranti
Bournemouth	Anglo-American Brush Corporation	Mordey Alternators
Derby	J. Davis and Son	Low Tension (Accumulators)
*Exeter	Exeter Elec. Light Co.	Thomson-Houston
Reading	Laing, Wharton & Down	Thomson-Houston
Thetford.....	Laurence, Paris and Scott	Low Tension
*Swansea	(Municipal)	(Not Selected)
*Lynmouth	C. Geen	Mordey Alternators
Glasgow (George-square)	Muir, Mavor and Coulson	Ferranti

* Those marked with an asterisk are only projected. † Municipal buildings only lighted; no public supply.

To this list may be added the town of FOLKESTONE, where the Corporation are now advertising for tenders for arc lighting.

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THE BOARD OF TRADE AND THE LIGHTING OF LONDON.

The following is a copy of the text of the memorandum recently addressed by the Board of Trade to the London Electric Supply Corporation and the Metropolitan Electric Supply Company:—

[Copy.]

"Board of Trade, Railway Department,
"London, S.W., November 23, 1888.

"Gentlemen: I am directed by the Board of Trade to state that they have had before them the application of [your] company for a license under the provisions of the Electric Light Acts, 1882 and 1888, in respect of an area comprising an extensive part of the metropolis. After a careful consideration of the application, the Board of Trade are of opinion that there are grave objections to the grant of a license for so large an area of the Metropolis, one of the most prominent of these objections being that no opportunity is afforded to Parliament to review the decision of the Board of Trade. In a matter affecting so many interests and such a large portion of the population of London, it is not in the view of the Board of Trade expedient that their action should be entirely without direct parliamentary sanction, such as is given when the procedure is by Provisional Order.

"In these circumstances the Board of Trade have come to the conclusion that they cannot properly proceed with the application referred to.—I am, gentlemen, your obedient servant,

(Signed) "COURTENAY BOYLE."

DYNAMO REGULATION BY MEANS OF A THIRD BRUSH.*

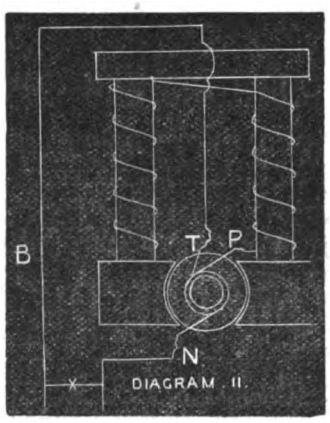
BY EDWARD CALDWELL, A.B., M.E.

(Concluded from page 219.)

The requirements for constant potential regulation are radically different from those necessary for constant current. Recurring again to Prof. S. P. Thompson's fundamental equation of the dynamo,

$$E = 4\,n\,A\,H,$$

where n and A are both constant, it is evident that if E is to be a constant H must also be a constant. Hence, for constant potential regulation the exciting current of the field coils must be a constant.



It is believed that the method here described for obtaining this result has not before been applied for this purpose. The arrangement is a very simple one, as shown in Diagram II. The third brush line passes through a low resistance, and is joined to the main line at the positive terminal of the machine, just outside the field-coils. In this case either no resistance or a very low one is placed between the third and positive brushes, and no automatic arrangement is necessary, as the point of junction is a fixed one. Diagram III. shows the connections as used in the experimental work.

The effect of using different resistances in the third brush line is shown by Tables 15 to 19, and curves 1 to 5, Plate C, plotted from these tables. The third brush remained fixed at 36deg. in advance of the positive brush, this being given as before, 12deg. lead. Curve 6 of the same plate is plotted from Table 20, and is the characteristic of the machine run as a series dynamo, reduced to the same speed as Tables 15 to 19.

* Revised abstract of graduating thesis, Sibley College, Cornell University, June, 1888. Reprinted from the New York *Electrical Engineer*.

	Volts.	Amperes in main line.	Amperes in field line.	Amperes in third br. line.	Ohms in main line.	Ohms in third br. line.	Angular advance of third brush.
Table 15.	59·	·63	3·37	-2·74	8	Only the lead wire.	36°
	59·	·83	3·40	-2·56	60		
	59·	1·14	3·42	-2·28	50		
	59·	1·29	3·31	-2·03	40		
	58·	1·64	3·16	-1·52	30		
	57·5	2·00	3·12	-1·12	25		
	56·4	2·44	3·01	-·57	20		
	53·5	3·10	2·78	·32	15		
	50·	4·00	2·12	1·88	10		
	46·4	4·87	1·64	3·23	7·5		
Table 16.	57·	·68	2·95	-2·27	80	1	36°
	57·	·87	2·93	-2·06	60		
	57·	1·04	2·89	-1·85	50		
	56·5	1·24	2·88	-1·64	40		
	55·8	1·66	2·84	-1·18	30		
	55·2	1·96	2·86	-·90	25		
	54·8	2·40	2·86	-·46	20		
	53·5	3·08	2·80	·27	15		
	51·	4·40	2·83	1·57	10		
	48·5	5·40	2·82	2·58	7·5		
Table 17.	54·	·60	2·23	-1·63	80	2	36°
	54·	·81	2·30	-1·49	60		
	54·	1·01	2·32	-1·31	50		
	54·	1·19	2·37	-1·18	40		
	54·	1·55	2·46	-·91	30		
	54·	1·91	2·56	-·65	25		
	54·	2·37	2·69	-·32	20		
	53·5	3·09	2·89	·20	15		
	53·	4·40	3·33	1·07	10		
	52·	5·58	3·75	1·83	7·5		
Table 18.	52·5	·61	1·79	-1·18	80	3	36°
	52·5	·79	1·90	-1·11	60		
	52·5	·97	1·97	-1·00	50		
	52·5	1·17	2·05	-·88	40		
	52·5	1·55	2·19	-·64	30		
	52·5	1·90	2·37	-·47	25		
	53·	2·35	2·60	-·25	20		
	53·5	3·06	2·86	·20	15		
	53·	4·40	3·59	·81	10		
	52·5	5·52	4·22	1·30	7·5		
Table 19.	47·	·57	·91	-·34	80	5	36°
	48·5	·73	1·10	-·37	60		
	49·	·96	1·31	-·35	50		
	50·	1·17	1·53	-·36	40		
	51·2	1·53	1·80	-·27	30		
	52·0	1·88	2·11	-·23	25		
	52·8	2·28	2·40	-·12	20		
	53·5	3·06	2·96	·10	15		
	53·5	4·42	4·08	·34	10		
	52·3	5·46	4·88	·58	7·5		

TABLE 20.

Volts.	Amperes.	Volts.	Amperes.
8	·20	53·5	3·06
37·3	·88	56·2	4·53
48·2	1·48	59·0	5·83
51·6	2·22	57·2	6·50

Curves 7 to 11 of Plate D are plotted from Tables 15 to 19 with external resistances as abscissæ, and current in the third brush line as ordinates, and correspond respectively to curves 1 to 5. Plate C Negative current is plotted below the axis of X and positive current above.

These curves and tables show: (1) that the current in the third brush line is, at first, with high external resistances, negative, having its highest value when the external resistance is infinite or when the main line circuit is open; that with decreasing external resistances it gradually decreases, passes through zero, and again rises in the opposite direction; (2) that the point at which the third brush current becomes zero is independent of the resistance in the third brush line, becoming zero in each curve at exactly the same external resistance, and that this zero point is the point at which the new curve crosses the series characteristic; (3) that increase of resistance in the third brush line reduces the regulating power of the third brush, the curve at the limit coinciding with curve 6; (4) that increase of resistance in the third brush line decreases the field current, and consequently the E.M.F., but that the external current is practically independent of the resistance in the third brush line;

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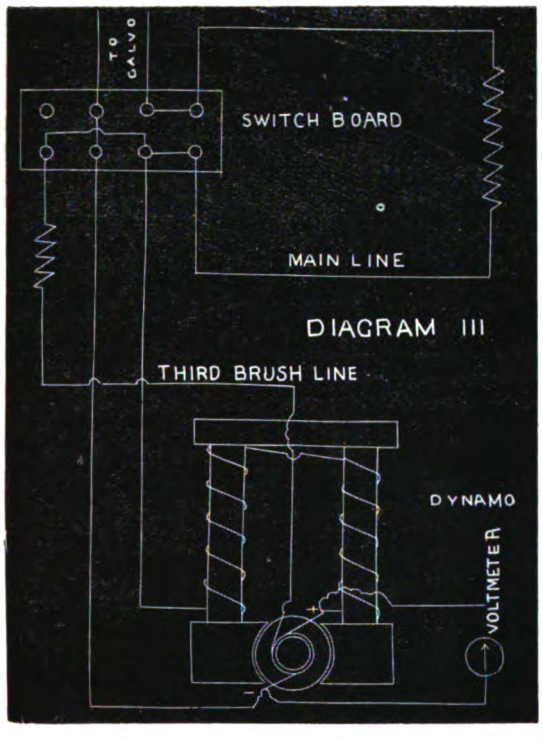
(5) that the most constant E.M.F. is produced when the third brush line has a resistance of about three ohms—in this case about twice that of the field coils. This resistance, however, will vary, not only with the resistance of the field coils, but also with the angular advance given to the third brush, and with the amount of current necessary to produce saturation—that is, with the quality and quantity of iron in the cores.

The explanation of these phenomena is slightly different from that already given for the changes observed in the case of constant current regulation. The same equation, however, is applicable. Using the same symbols as before, equilibrium will exist between the ends of the third brush line, when $E_d = E_i$, or $C'R' = 4\pi H'A'$. In this arrangement R', which is here the resistance of the field coils only, remains a constant. A decrease of A' by bringing the third and positive brushes nearer each other, or, within certain limits, an increase of C', will make $E_d > E_i$ and make the third brush positive. If now A' remains constant and C' be increased by a decrease of the external resistance, H' will increase in direct proportion as long as the iron of the field-magnets is in the unsaturated condition, and there will be no change in the value of the equation, $E_d = E_i$. But as soon as the saturation point is reached, H' becomes practically a constant, and further increase of C' will make $E_d > E_i$ and the third brush positive. In Tables 15 to 19 the field-magnets are fully saturated when $E_d = E_i$, and hence *any* increase of C' makes $E_d > E_i$. Had A' been much smaller this result would not have been obtained.



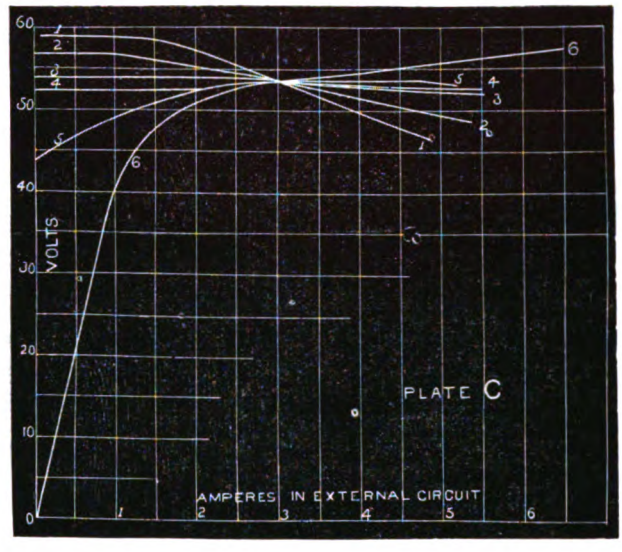
The two opposite changes will make $E_d < E_i$ and the third brush negative, viz., an increase of A', or a decrease of C'. A decrease of C', however, will produce this result only when, as before, the iron is fully saturated. This is shown in the first part of Table 19, where the field current was not sufficient to produce saturation of the magnets, and, as a result, the current in the third brush line remains practically unchanged, while C' undergoes considerable variation.

It is evident that the potential of the two extremities of the third brush line is independent of the resistance of the line, and hence any variation in this resistance will have no effect upon the point at which its two ends will be at equal potential. It does, however, determine the amount of current flowing in this line, and hence the amount flowing in the field coils; since when the third brush is negative it adds its current to that of the field coils, and when it is positive the current in it is shunted *from* the field coils, as in the constant current regulation. This resistance must be low enough to allow of complete saturation of the field-magnets.

Here, again, we have an arrangement which is in reality equivalent to a compound-wound dynamo. Referring to Diagram II. and the first line of Table 17, it will be seen that the field coils perform the part of series coils in carrying ·6 of an ampere from the positive brush P around the external circuit to N, and at the same time, as shunt coils, carry 1·63 ampere from P around the field-magnets to T, the third brush. The same three types of dynamos are here brought into use, viz.:—

1. Series dynamo + cumulative shunt coils.
2. Plain series dynamo.
3. Series dynamo + "differential shunt" coils, and the conditions under which each is brought into use are precisely like those already met with in regulation for constant current.

As was pointed out in the discussion of the constant current regulation, the application of the third brush necessarily interferes with the symmetrical flow of current in the armature, those coils lying between the third and positive brushes carrying more or less than the other coils, according as the third brush is negative or positive. In properly constructed dynamos this should produce no detrimental effect. It should, however, be taken into account in dynamo design when computing the size of armature wire from the amount of current it is to carry, for it is evident that in this case one-half the total current in the external circuit is not the maximum current which the armature coils must carry. A similar remark applies to the size of wire for the field coils.



A decrease of the resistance of the field coils would decrease the loss of potential between the positive brush P (Diagram II.) and the point B, and, the potential of T remaining constant, would increase the negative current in B T, and, other things being the same, the lower the resistance of the field the lower the resistance of the external circuit must be made before B and T are brought to the same potential, or, in other words, before the new characteristic crosses the series characteristic; and if this point is not

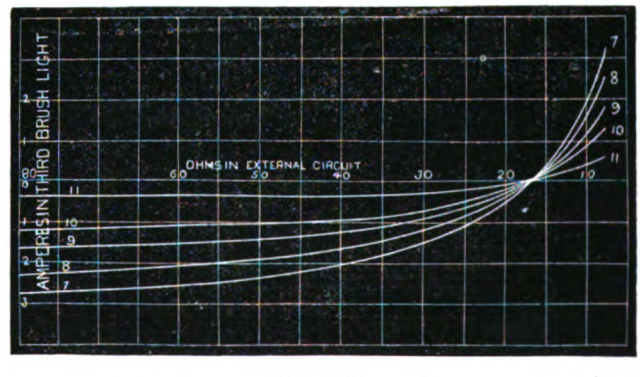


PLATE D.

reached within the limits of the machine only the first of the three types of dynamos mentioned above is made use of. The same effect is produced by giving increased advance to the third brush, thus lowering its potential. Increased resistance of the field or decreased advance of the third brush will produce opposite effects. It will be found that whatever the field resistance or the advance of the third brush, there will be a corresponding resistance for the third brush line (and this in conjunction with the field coils may be regarded as the shunt circuit of a compound dynamo), for which the machine will produce a constant E.M.F.

Prof. S. P. Thompson has observed that the efficiency of any compound-wound dynamo for constant E.M.F. is very nearly a constant. Using his equation for efficiency, this is very nearly obtained from Table 19 and curve 5, Plate C, and this is probably very near the true curve for constant E.M.F. at the *terminals* of

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the machine, the volts here being the difference of potential between the brushes.

It is hoped that at some future time an experimental study, similar to that described above, may be made of third brush regulation for electric motors for both constant current and constant potential circuits. The field is an inviting one, and cannot fail to be productive of useful and practical results.*.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 22nd*, 1888.

The Western Union Telegraph Company has just issued its statement of business for the quarter ending the year. Owing to the unusual amount of work done at the time of the presidential election there is a notable increase, and the net revenue is set down at $1,650,000, being an increase of $150,000 over the corresponding period of 1887. It also appears that the net revenue for the quarter ended September 30th is $157,000 above the estimate made three months ago, so that altogether the company is in good shape. The earnings are at the rate of over 7 per cent. per annum, but the old rate of 1¼ per quarter has been declared.

The American Bell Telephone Company has also just declared its regular quarterly dividend of 3 per cent. It is understood that the company is earning at the rate of 24 per cent. per annum, but the stockholders seem fairly well satisfied if they can draw, as they do, with the "bonus" a modest 16 or 18 per cent. on their investment.

As many of your readers have doubtless learned by actual observation, our lakes that border the northern frontier are big inland seas. Even if they have not seen them, they have perhaps formed some idea of their magnitude from the ordinary figures that are published; but unless one actually sees it little idea can be formed of the vast commerce which has grown up along the shores of the lakes, and which commands the services of hundreds of large sailing vessels and steamers. The great lakes have their storms, well nigh equalling those of the mid-Atlantic, and they have also a lighthouse department as important as that which guards our coasts. The first of the lake lighthouses in which the electric light has been placed is that which has just been put up at Chicago, which is not less busy a port than it is a railroad centre. This new lighthouse is near the North Side pumping station and the new crib of the waterworks. It is a skeleton surmounted by a circular glass lantern, which carries twenty-four 32 candle-power lamps, mounted in a circular silver glass reflector, which throws a beam for eight miles. An interesting feature of the work is that the current is conveyed out to the lighthouse by five lead-covered cables laid in a tunnel, and another interesting feature is that the current is used for sounding fog alarms; in other words, a small motor has been put in, which strikes a fog bell of 600lb. weight suspended in the lantern. This bell is struck by a 20lb. hammer, which is raised and dropped eight times a minute by a revolving cam. The motor is securely bolted underneath the floor of the lantern, and is under control distinct from that of the lamps. The service given and the results obtained appear to be very satisfactory.

While on the subject of marine motors I may as well make note of the sensation which is being caused here by the publication in one of our weekly journals of a weekly novel by Mr. Frank R. Stockton, entitled "The Great War Syndicate." The idea of the story is that at the close of the present century, in spite of the work recently done by Mr. Joseph Chamberlain, war breaks out between the United States and Great Britain and Canada over the Fisheries. The outbreak of hostilities comes like a thunderbolt, and finds the country, though highly prosperous, thoroughly unprepared for the emergency; while England is represented as being ready with any number of fine ironclads, Lord Randolph Churchill to the contrary notwithstanding. The swift British cruisers chase and capture American merchantmen, and the angry enthusiasm of our people runs high, while the Government becomes daily more anxious and despondent. At this juncture a number of our leading wealthy men meet together and form a syndicate, make a contract with the Government, and take off the hands of the little army and navy the job of fighting the fleets and troops of England. This will strike you as an essentially American way of looking at things; but, after all, as the bankers generally carry on the big wars, there may be nothing extremely original about it, so far as raising the money is concerned. But this war syndicate not only supplies the money for the work, but the energy and the brains. It gets hold of some important inventions, and launches a fleet composed of two peculiar classes of ships. In these ships, which are called respectively "repellers" and "crabs," electricity has the star *rôle*. The repellers are provided with gigantic guns, operated by electric motors and projecting instantaneous motor bombs which wipe out everything they strike, from a ship to a city. The crabs are monitor-like craft, also provided with "electric engines," which operate long nippers. The object of these nippers is to seize the rudder gear and screw-shaft of every ship of the enemy, and in this manner to disable them and render them an easy prey. According to Mr. Stockton's story, a small fleet of these extraordinary craft blockaded a Canadian port, and there not only shaved big forts clean off the face of the earth, but shattered and bore away the rudders and screws of the ships of the defending men-of-war, putting them in such a condition that they were utterly unfit for service. The story goes on to describe how the British Admiralty equipped as quickly as possible its new ships and met this new style of warfare; but no great success attended their efforts, and the first part of the story leaves the syndicate practically master of the seas. There is some clever work in Mr. Stockton's fiction, and although it is very incomplete and absurd in some of its details, it has set the public thinking, not only of the insecure state of our coast defences, but as to what the navies of the future are likely to be, with all the improvements that electricity is now furnishing them. It will be seen that Mr. Stockton is working on the lines of Jules Verne, adding to popular science a marked dash of what is known as "American humour."

One of the leading sensations this week has been the publication in some of the daily papers of negotiations that have generally been known to be in progress very quietly for a reorganisation and consolidation of all the big Edison interests in this country. It is understood that the conduct of the negotiations has been in the hands of Mr. E. H. Johnson, the energetic president of the Edison Company, and Mr. Henry Villard, a very able financier, at one time prominent in connection with the Northern Pacific Railroad, and to-day one of the magnates of Wall Street. As you are probably aware, most of the actual work of supplying material for the Edison system has been done by subordinate manufacturing concerns, which have made handsome earnings and profits; and the proposition now is to bring all the interests together under one management, and issue stock to cover the whole. It is said that the new stock will be £2,500,000, and that in view of the contemplated change the present Edison Stock has already gone up to 170. From the way the papers talk it might be inferred that a scheme is afoot to consolidate all the electric light interests of the country, but there seems no reason whatever for the suggestion.

Speaking of Edison matters reminds me that Mr. W. J. Jenks, director of the Edison Standardising Bureau, read a Paper before the American Institute of Electrical Engineers this week on "Six Years' Experience with the Edison Chemical Meter." The Paper drew a large audience, and was well received. It contained an abundance of data, both scientific and practical, the latter predominating, and was freely illustrated by lantern. Mr. Jenks adduced conclusive evidence in support of the superiority of a meter system for selling current, as compared with a flat rate or contract basis; and he was not less successful in proving that the Edison meter had been an efficient piece of apparatus for its purpose. He stated, however, that it was intended to introduce a number of improve-

* *See* U. S. Patent Specifications Nos. 387,194, and 387,195, of July 31, 1888.

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ments, and outlined them. The illustrative part of the Paper was made the more interesting by the inclusion of a number of views from patent and other drawings, showing the evolution of the Edison Chemical Meter, and the ingenious efforts made by Mr. Edison to utilise sundry principles in bygone years. Altogether the Paper is a highly valuable addition to the fund of information on the meter subject.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *December 26th*, 1888.

At the meeting of the Conseil Municipal which took place on Saturday night last, permission to lay cables in the streets for the distribution of electric current from central stations was, after a long discussion, granted to the following companies:—The Compagnie Continentale Edison; the Compagnie Parisienne (Victor Popp); the Société Anonyme pour le Transport de la Force par l'Électricité (Marcel Deprez); the Société d'Eclairage Electrique du secteur de la Place Clichy (A. Koechlin and Georges Fournier); the Parisienne Electrique, &c. (M. Censier, Electrical Engineer.) The ground covered by these authorisations is entirely on the right side of the river, and comprises nearly half Paris, from the Bois de Boulogne on one side, to the Quai de Bercy on the other. I have been told that permission has been asked for a district on the left side of the river, but the demand was not discussed on Saturday last. Looking at a map of Paris, one is astonished at the area already asked for. One must also not lose sight of the fact that the authorisations have been granted under a security of 300,000fr. in each case, and under an agreement to have cables laid in all the large streets within two years, and within four years in every street where 10 lamps are asked for per every 10 metres.

Although the decision of the committee for the electrical lighting of the Halles Centrales has not been yet officially announced, I can still give you the names of some contractors whose tenders have been accepted:—Belleville and Company, for boilers; Weyher and Richemond, and Lecoulteux and Garnier, for steam engines; the Edison Company for the low-tension currents, and the Ferranti system for the transformers. Nothing has been decided up to now as to the lighting of the pavilions of the Halles with arc lamps, but it is probable that the preference will be given to the Thomson-Houston system.

The number of private installations in this city is increasing rapidly, and some of them are rather important, such as the underground floor of the Crédit Lyonnais, with 300 lamps; the Conservatoire Naticnal de Musique, with 390; the Society of Civil Engineers, with 100; the Piscine Rochechouart, with 45 Thomson-Houston arc lights; the Bouillons Duval, the Bouillons Parisiens, the show rooms of the Choubersky Company, and many others.

In a few days the station at the Palais Royal will commence operations. It will start with 2,000 incandescent lamps, but this number will rapidly increase as more plant is installed. The machinery will consist of eight Belleville boilers and eight Weyher and Richemond vertical steam engines, running at 130 revolutions a minute, everyone of them being directly connected with an Edison dynamo of 800 amperes and 110 volts, running at the same speed.

In the provinces the municipalities and inhabitants regard the electric light with more favour than ever; Nimes, Troyes, Perigueux, Grenoble, Avignon, and many other smaller towns are studying the means of distributing electric current for public and private use, and there is no doubt that this tendency will greatly increase after the favourable vote of the Parisian Conseil Municipal.

Most of your readers will no doubt have seen a good deal of late in the papers about M. Zédé's new submarine boat, the "Gymnote." At a recent meeting of the Académie des Sciences Admiral Paris read a short Paper on this interesting subject, and in the course of his remarks showed himself very enthusiastic in this matter. Amongst other things Admiral Paris said: "In short, we are able to say that the 'Gymnote' moves and steers equally well above or below the water, that it can be kept accurately at the desired depth, that its speed is all one could expect, that respiration is unimpeded, and that it is easy to see, down to a certain depth. M. Zédé says that Captain Kreb's electric motors are marvels of lightness and precision, and that this important part of the boat has been carried out in a most masterly manner. The energy available amounts to 240 horse-power-hours. So complete a success would have been impossible without the scientific ingenuity and minute care which M. Romazoff, naval engineer, of Toulon, brought to bear upon every detail. Here, then, we have a solution of the submarine-boat problem. The first step has been taken; better work will be done in the future. But even as it is the 'Gymnote' is capable of rendering good service."

NOTES FROM BRUSSELS.

(FROM OUR CORRESPONDENT.)

BRUSSELS, *December 29th*, 1888.

A syndicate of electricians which has recently been formed has offered to assist the Brussels authorities in their deliberations upon the central lighting station question. The syndicate made its proposal in the following terms:—"We learn that the city of Brussels is seriously studying the question of central stations for the distribution of electricity for light and power purposes. This question is of such vital importance to the town as a manufacturer of gas, and to the general welfare of the inhabitants, that we offer our assistance without hesitation. With this object in view some of us are willing to hold ourselves at your service in order to elaborate a well-considered plan in concert with any delegate you may think fit to appoint. On the other hand, we think that the national interests which we represent are worthy of your consideration; in fact, being all of us producers, and employing in our workshops at Brussels a large number of hands, for whom we have created a new and prosperous trade, we greet the projected central stations as a means of employment to a still larger number of workmen, and as affording a new outlet to the labouring classes of Brussels." The municipal authorities really do seem to be bestirring themselves with regard to the electric light. For some time past it has been proclaimed that the day was at hand when electricity would prove a serious rival to gas, and a menace to the revenue drawn by the town from its gasworks. The time which has so long been announced as at hand seems now to have actually come. The town of Dolhain, for instance, in the Province of Lemburg, is at the present moment lighted by electricity, and everyone is satisfied, the consumers as well as the Communal Treasury. Our local authorities are awake at last; better late than never. But to return to the syndicate. It is composed of the five principal electrical firms in Brussels, and taking into consideration the variety of systems advocated by the several members, it is tolerably safe to predict that it will meet with no greater success than its predecessor. It will, perhaps, be within the recollection of your readers that a previous attempt to form a syndicate came to an untimely end when the contract for the lighting of the Gare du Nord was put up to tender, which shows that there are no real means of reconciling conflicting interests, which invariably lead to disunion at the critical moment. Although the composition of the syndicate has been somewhat altered, the facts are still the same; the same divergent interests are there, and it appears to me as if the only *raison d'être* of the new combination was to allow the several adherents to keep closer watch over each other. One factor ought certainly not to be lost sight of by the syndicate, namely, that the city authorities, as in the case of gas, will certainly run the central stations themselves, so that the only profit to be looked for by outsiders will be that arising from the sale of material. It appears to me, therefore, that the syndicate is in a position somewhat similar to the gentleman who offered a bear's skin for sale before he had shot the bear. Moreover, the syndicate is certainly no promoter of national industry, comprising, as it does to a large extent, representatives of foreign firms whose wares have already flooded our market, and which generally defy home competition by their cheapness, and, I may add, by reason of the favourable support accorded to them in high quarters. The authorities will not lack advisers, and will come to their final conclusion with a full knowledge of the facts. I think it, however, advisable to place this matter, as far as the syndicate is concerned, upon its true basis, and to show what would inevitably be the result of the success of these five firms, who are anxious to divide the lighting of all Belgium between them.

An installation has just been started at Ghent which may prove of great importance to the maritime trade of this town. For some nights the light of several large arc lamps has rendered the night-work on the quays as expeditious as that carried on during the day. The regular service will not begin before the 1st January, from which date the town authorities will furnish the light to the ships using the dock. Formerly the steamers arriving at this port, if they wished to unload without delay, were obliged to do so as best they could by the light of petroleum lamps or gas lamps; now the work can be carried on as easily by night as by day, and the advantages arising from these facilities cannot be overrated. Here are a few details concerning the installation. The engine and dynamo are placed in the room containing the hydraulic machinery connected with the dock cranes, the engine being a Parsons steam turbine running at 10,000 revolutions a minute. The lighting is done by eight 1,200 candle-power Dulait arc lamps, placed on iron masts 10 metres high. In addition to the arc lamps there are several portable incandescent lamps enclosed in lanterns, which are of great use in lighting up the holds of the ships. The installation was carried out with great rapidity, for the work was only begun on Thursday, 6th December, and the lights were running on

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the following Tuesday. The system adopted is that of M. J. Dulait, director of the Société Électricité et Hydraulique de Charleroi. This company, I may mention, is very busy at present with other installations in East Flanders, and has successfully competed in several instances with one of the foreign companies which have their head-quarters at Brussels.

M. Cordenraus, the manager of the Central Hotel, has decided to light his splendid building facing the Bourse by electricity; the installation will comprise 15 arcs, and from 200 to 300 incandescents. The question of motive power has not as yet been definitely decided, but I hear that gas engines will most probably be used, owing to the difficulty of obtaining the requisite permission for the erection of boilers and steam-engines. The arcs will be used on the balconies and in the courts and halls, the incandescents being confined to the café, dining room, bed rooms, and cellars.

The announcement of the Exhibition awards has been followed by a short report on the electric lighting arrangements. With wise prevision the promoters of the Exhibition called upon every system to compete for the lighting of the buildings and grounds, no system being excluded *à priori*. The result of this was to give the public an unequalled opportunity of seeing the various methods of lighting running side by side, and to show them that, even where the force of circumstances necessitates rapid work, no danger need be feared if only the matter is entrusted to competent persons. In your country and in America the high-tension system has gained great favour, combining as it does the two *desiderata* of modern industry, economy and rapidity. With us, however, the case is different; the public is not so familiar with the sight and use of machinery, consequently the idea of high-tension currents is not liked, and low-tension systems are more in harmony both with public opinion and with the law. Another reason for the preference which is accorded on the Continent to low-tension systems is the inexperience of the workmen. We have got into a groove in this respect, and although we have no doubt made the system as perfect as it can be made, nothing can compensate for its expensive and cumbersome character. Now, in my opinion, one of the chief claims which the promoters and organisers of this large scheme of electric lighting at the Brussels Exhibition have to our gratitude, is that they clearly demonstrated the harmless nature of any properly erected electrical installation. A dozen unknown systems were run in close proximity to one another, and yet not a single accident occurred, a result which reflects great credit on M. Bandsept, who was in charge of the running of the wires as well as of the working of the whole electric light installation.

MM. Mourlon Frères have just formed themselves into a company under the title of Compagnie de Télégraphe et de Téléphonie Internationale. The new company will be under the management of M. Ch. Mourlon, M. Van Rysselberghe being the consulting engineer. Besides its telephonic and telegraph business, the new company intends to go in for electric lighting by means of batteries or dynamos, and it will also turn its attention to the sale of phosphor-bronze wire.

The *Etoile Belge* has just scored a point in the race for early news. On Friday last it published in its second edition at 10 a.m. full details of Prado's execution, which appeared in the French papers some fifteen hours' later. This unusual rapidity was due to the special telephone service of the *Etoile Belge*.

I noticed on MM. Mourlon's stall at the recent Exhibition an ingenious arrangement for checking the movements of night watchmen. It consisted of a long drum, driven by clockwork, and covered by a roll of paper. Close to the drum there were just as many electro-magnets as there were signalling points. Each of these electro-magnets was armed with a small punch, and whenever the button at the signalling point was pressed the paper on the roller was punched, and by means of the divisions on the paper it was possible to tell within a minute or two when the signal was transmitted. Any tampering with the wires or apparatus caused an alarm bell to ring.

CORRESPONDENCE.

ELECTRICAL DISSIPATION OF FOG.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The remarks made in your editorial last week (page 213) on the inertness of people in attempting to dissipate fog by discharging electricity into it are well justified, and one of the persons most inert in the matter has been myself. I have been thinking of making the attempt ever since the Montreal meeting of the British Association, but hitherto I have been deterred, principally by the initial expense. Your surmise that the whole thing could probably be done for £10 by no means agrees with my estimate. In practice I find that hardly anything can be done for £10; and for a trial on any reasonable scale I estimate that something more like £1,000 is necessary.

A good many preliminary experiments appear to me necessary before one can decide what is the best way of getting the electricity up. A Wimshurst machine is all very well, but the quantity it is able to supply would hardly be likely to make much impression on the atmosphere at large. I am by no means sure but that a battery of an enormous number of cells would not be a more likely plan.

However, I have gone so far as this: I applied some month or two ago to the trustees of the "Elizabeth Thomson Science Fund" in America for £100, to cover part of the cost of a room and assistant and power and a large Wimshurst machine, with which to make some preliminary trials. The result of this application is not yet known.

As soon as I am able to adduce evidence of a reasonable prospect of success I propose to move for a committee of the British Association, or, better, of the Royal Society, to act as a recipient and trustee of some considerable sums to be expended on really large-scale operations. I apprehend that there would be little difficulty in obtaining funds for the purpose if one could hold out a distinct prospect of success. But at present my experience is confined to the clearing of a smoke-filled room; and though the ease with which this is done raises one's hopes as to what can be done in a stagnant atmosphere, yet, considering the enormous space to be affected, and the multiplicity of points which may act as dischargers, unless the supply is taken to a considerable height, I have not liked to bring the matter prominently forward, either before my own friends here in Liverpool or before the public at large. I hope, however, to be able to do so with a good conscience before the arrival of 1890.

OLIVER J. LODGE.

University College, Liverpool, 1st Jan., 1889.

[In mentioning an expenditure of only £10 we had in view merely a preliminary experiment, chiefly in order to determine whether a mixture of aqueous vapour and soot is at all tractable to electrical treatment. Everyone will, however, be pleased to hear that Dr. Lodge by no means despairs of success. In the dense fog of the last night of the old year it is said that in some of the London theatres the stage was scarcely visible from the back of the house; so that even if out-door operations are unsuccessful, there would still remain a limited, but still a very useful, field for its utilisation.—ED. *E.*]

ELECTRO-MAGNETIC SHUNTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: M. Godfroy, in the *Comptes Rendus* for November, 1888, has suggested the use of an electro-magnetic leak, possessing considerable self-induction and fixed at the entry of the wire into each station, to improve the speed of working through long wires. I think if he were to experiment a little more he would find that it would have a very small effect compared with the effect of a shunted condenser such as we use in the Post Office service. I experimented with leaks, electromagnetic and otherwise, some years ago both for automatic and telephone working, and I found that simple resistance leaks had a more beneficial effect upon rate of working than electromagnetic ones. The following experiment is instructive:—

R—Resistance of circuit	1,782ω	
K—Capacity of „	54 mfd.	
K R	96,228	
E.M.F.	100 volts.	
Speed by calculation ..... $\left\{\frac{10,000,000}{K R}\right\}$	104	words per min.
„ without leak (actual)	107	„
„ with 100ω leak (plain)	130	„
„ with 570ω „ „	125	„
„ with 570ω (electromagnetic)	125	„
„ with shunted condenser	177	„

($r = 8,000\omega$, $K = 2{\cdot}75$ mfd.)

—Yours, &c., W. H. PREECE.

G.P.O., January 2, 1889.

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FLASHED FILAMENTS IN LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Has anyone observed that the result of the so-called flashing process is necessarily to produce a conductor which tapers to the ends? Wherever the temperature of the surface is hottest, for any cause, there a more rapid deposition of carbon will take place; and where the temperature is lower a less rapid deposition will occur. Now, consider a simple arched conductor, which we will suppose to be of initially equal section from end to end. When rendered incandescent, the end portions, being connected to non-incandescent mountings, will be cooled by them. Those parts which are subjected to the end-cooling will necessarily be at a lower temperature, and will therefore receive a less thick deposit of carbon. Again, in the case of conductors which are bent, not merely into an arch, but into a loop of one or more turns. Those portions of the conductor which lie near to one another will radiate to one another, instead of merely radiating out to cooler objects. They will consequently help to raise one another's temperature. Were the conductor, then, initially a wire of perfectly uniform section, those parts which are thus mutually heated will tend to receive a thicker coating of deposited carbon than the straight limbs leading to the mounts.

In every case the result of flashing will be to so build up the size of the conductor that every part shall glow with equal radiance, in spite of its accidental position, whether subjected to a cooling effect or to a heating effect from the adjacent portions of the lamp. Flashing will not, as often alleged, reduce all portions of the conductor to equal size or equal resistance per unit of length, and it weakens the conductor mechanically by leaving it thinner near its mountings.

The existence of this tapering structure can be actually observed by the eye in some flashed lamps, and is capable of measurement by a micrometer gauge.

The following measurements were made by the writer upon a flashed 105-volt "Victoria" lamp. Measurements bracketed together were made at the same point in two diameters approximately at right angles to one another:—

	Diameter in millimetres.		
At bow of loop	·145, ·150	mean	·1475
Half-way down limbs	·150, ·140		
" " "	·135, ·150	"	·1437
At end, near mount	·095, ·105		
" " "	·110, ·105		
At other end, near mount	·090, ·100	"	·1012
" " " "	·105, ·100		

In another similar lamp the mean diameter of bow and limbs of the arch was ·130 millimetre, and that of the ends close to the mount ·100.—Yours, &c., SILVANUS P. THOMPSON.

20, Arundel-gardens, January 1, 1889.

ELECTRICAL DEFENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with interest the leader in your issue of November 9th, entitled "Electricity our Defence." If there is a favourable opportunity will you kindly mention the following:—

By implication I am credited with having, in conjunction with General Abbot, assisted in the experiments which led to the adoption of the low-tension primer having the platinum iridium bridge. Much to my regret I have not had the honour of working with the General in this direction, he having completed the experiments long before I commenced the development of the "pneumatic gun."

Whilst of the opinion that we could devise a "range-and-position-finder" capable of doing the work done by that devised by Major Watkins, Royal Artillery, I do not wish to underrate his achievement in the least. I know it to be a *very difficult* problem to solve, and you would oblige me, if opportunity presents itself, to quote just what I said in this respect:—

"I think it possible that some of our own ingenious electricians could produce apparatus quite as efficient as that of Major Watkins. I do not, however, wish to be understood to belittle the ingenuity or the feat accomplished by Major Watkins. It is a problem not to be lightly approached; but I have sufficient confidence in our own skill to believe that we also could solve the problem."

I send by this mail a corrected copy of my Paper and the discussion, there having been a number of mistakes in the stenographer's notes as previously published in the American press.

I did not state definitely my conclusions as to the use of the electric search light, as I believe it still to be an open question whether it can be used advantageously at all times. The Lucigen, or similar light, if planted at some distance from the works or ship, appears to me to present many advantages over the electric light in not marking definitely the exact position of the defence, and in better showing the approach of attack, when within the zone of the diffused light.—Yours, &c.,

E. L. ZALINSKI,
Captain 5th Artillery, United States Army.

Fort Hamilton, New York Harbour,
December 16th, 1888.

BLONDLOT AND CURIE'S ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of December 28 you have a note on a modified electrometer devised by Messrs. Blondlot and Curie to give continuous *power* indications on a circuit with a variable current, and thus do away with the two readings required. As far as I can gather from the account the modified electrometer is really a combination of two electrometers acting in combination. The principle of such an arrangement is as follows:—

The usual measurements are made by connecting the quadrant to the ends of the circuit under measurement, and the needle to one end of a non-inductive resistance, the other end of which is connected to the point where the circuit under measurement commences. A second reading is made by connecting the wire from the needle to another point (say half-way) in the non-inductive resistance.

The two readings ϕ and ϕ_1 are then represented by formulæ of the form

$$\phi = V \times (C + K),$$

$$\phi_1 = V \times \left(\frac{C}{2} + K\right),$$

where V a E.M.F. acting on the circuit and C a current flowing in the circuit; whence

$$\phi - \phi_1 = \frac{VC}{2}.$$

Now the deflections ϕ and ϕ_1 are simply the measures of forces acting. Hence, by connecting up two separate electrometers suitably connected with their needles on one suspension, these forces may be added mechanically, instead of by taking separate readings and performing the addition on paper.

This idea is not new, for in 1882, I think, whilst studying under Prof. Ayrton at the Cowper-street Technical School, when he described the method now well known with two readings, I suggested the above method to him, proposing to carry it out by using two separate sets of quadrants and needles suspended by the same thread; and in 1886, in a Paper read by me at a supplemental meeting for students, at the Institute of Civil Engineers, I described the same method.—Yours, &c.,

LLEWELYN B. ATKINSON.

Woodfield-road, Harrow-road, London, Jan. 2, 1889.

[Mr. Atkinson's method seems a good one so far as it goes, but we do not think that he is correct in saying that the principle of the Blondlot instrument is identical; the division of the non-inductive resistance does not occur in the latter method.—ED. *E.*]

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ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I fully appreciate Mr. Reckenzaun's kindly expressions towards me, the which I fully reciprocate towards him personally, and should not have written my slight criticism upon his efforts had the article been signed by himself. Mr. Reckenzaun seems to be labouring under several difficulties, the most prominent of which seem to be getting round or evading the patents held by ourselves and the Electrical Power Storage Company and M. Julien, and persuading the public that he has not only done this but found something better. I have myself seen very similar plates to that he has adopted made by the Electrical Power Storage Company, either in the day of his connection with this company or previously, these plates having been set aside on account of their difficulty and cost of construction. The advantage for the form of plate, viz., the ease with which it may be bent, is practically small, as the plates are not intended to be bent, and must be prevented from this. Were they bent, although the peroxide might not fall from them, the electrical contacts of the oxide with the grids would be much disturbed, and no good would result to the plates, while the plates after this mode of construction must be greatly reduced in active area in comparison with such a grid as I sent with my first letter to your office. I fully appreciate the efforts of Mr. Reckenzaun, having myself from the very earliest period been interested in this question, and although not a prominent actor before the public, I have been constantly engaged, through many channels, in this work.

The exception taken to my statement as to the tendency of cars to leave the road when drawn independently upon each axle on passing sharp curves and points may be warranted, although my experience is to the contrary, and I have found that cars driven by the two axles (the two axles being coupled) have not shown at all similar tendencies. The statement that two motors made of the same weight of material would give an equal efficiency is approximately correct, but the speed of rotation would be very different, and one of the great advantages of the larger motor is in it being possible to reduce the speed, and I have found no difficulty in being able to meet the necessities of space beneath the tramcar with one motor. Respecting the mode of driving, I admit that the quietness obtained by screw-gearing is an advantage, but on seeing this exhaustively tried, the amount of heat generated was so great an inconvenience (although the screw was run in a bath of oil), and the quantity of energy required to do an equal amount of work to the ordinary chain gearing was so excessive, as to condemn it, and this under identical circumstances. I agree with Mr. Reckenzaun that the commercial success of electrical traction does not depend upon a few per cent. more or less in efficiency, but upon the total cost of traction (inclusive of repairs and renewals), and freedom from breakdowns, &c. Mr. Reckenzaun seems to think me personally inclined to evil towards him by denouncing his method of changing the field connections; nevertheless, he states in his reply that the resistances of the fields of his motors are so excessive that he immediately cuts these down to a fourth after starting; yet he objects to using resistance, and then falls below the saturation point of his magnets. These two statements prove the ground for my assertion that this is not an economical mode of using the E.M.F. of the battery; *but it has the merit of being another mode to that of M. Julien.* It has been said that Julien's mode of connecting up batteries is objectionable, which, in practice, I have not found. The only objection to this method is the cost of the switch and its liability to derangement; when used upon tramcars with a suitable motor it effects the best economy of the batteries I have seen or know of. I would welcome public competitive trials of electric cars and any method of making known that which is best for the purpose, and I do not desire for a moment to deprecate the efforts of another; but the long labours of myself and my company in this direction, and the property of my company and the Electrical Power Storage Company in their accumulator patents, the long connection I have had with M. Julien in working at this traction problem, and a strong desire that the investing public shall be thoroughly cognisant of all its merits, rule me in this communication.—Yours, &c.,

T. PARKER.

Wolverhampton, January 1, 1889.

P.S.—In my first letter, *The Electrician*, December 21st, 1888, fourth line from bottom, the word printed "charging" should be *changing*.

ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As one who has had considerable experience of every kind of the difficulties of initiatory work in electric traction I cordially endorse the concluding observations in Mr. Reckenzaun's letter in *The Electrician* of the 28th December last.

Mr. Reckenzaun says:—"I would rejoice to see other men successfully working——. I think it bad taste to run down in newspapers the work of competitors. We get very little encouragement from the public at large. The prejudices to be overcome are very great, and there is no need of the same being augmented by those most interested in the development of electric tramways."

The subject matter and the full meaning of these observations should be well borne in mind by all who seek, directly and indirectly, to benefit by the general introduction of electrical locomotion. I made similar observations in a letter published in the *Electrical Review* some time ago. There is no doubt that every success, no matter by whom attained, greatly helps all interested. We are on the eve of an enormous development in electrical work from the working of all kinds of vehicles. An immense amount of capital is required in the work to make it move ahead at a satisfactory rate, and the more capital which is successfully employed in the work the better. There is no doubt that with the guarantees which manufacturers are prepared to give for the maintenance of their appliances electric traction has in it enormous economical capabilities, and the time is very close at hand when this will be generally recognised, and the mere economy will force its general adoption on a most rapid scale.—Yours, &c.,

15A, James-street, Haymarket, S.W., RADCLIFFE WARD.
2nd January, 1889.

BATTERY TRANSFORMERS AND THE VIENNA INSTALLATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The theoretical conditions of the battery transformer system inquired into by M. Paul Hoho, and commented on by you in your last number, deserve more careful consideration than has hitherto been given to them. I was greatly disappointed to find no one take special notice of these conditions in the course of the discussions on my Paper last year, so that I now have great pleasure in explaining how the difficulties mentioned by M. Hoho are got over in practice. In the very simple case of the Le Mans installation, where there are only two batteries in series, all that is necessary is to provide a peculiar form of transfer-switch, which at one movement transfers the load from one battery to the other, *i.e.*, after the transfer the battery which was previously giving the heavier discharge now gives the lighter one; but at Vienna, where there are four batteries in series, the matter is not quite so easily arranged. In this case the load is equalised as much as possible by a large plug-board, lining the walls of the distributing switch room. By this means any of the circuits can be switched on to any of the batteries. At Vienna also one or more batteries, if the demand on them is small, can be switched out of the charging circuit, the speed of the engine being automatically reduced in proportion to the decrease of the charging E.M.F. necessary for the reduced number of batteries, by means of Willans' constant-current electric governor. As you truly state, a great deal depends on the watchfulness of the attendant in charge of the switch room in both these cases, and I for some time have been devising means to make the switching arrangement automatic. Every additional month's experience at Vienna only serves to confirm the opinions I have previously formed as to the great value of the battery-transformer system, both in its great economy and in

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the high sense of security against stoppage of the light which it affords to everyone. I think I am justified in saying that even at the present moment the fuel consumed per net E.H.P. delivered at the lamps contrasts most favourably with any of the direct systems or any of the alternating transformer systems either in England, America, or on the Continent. I am not aware of any difficulties having presented themselves in the working, and the wear and tear of the E.P.S. accumulators has so far not been excessive.—Yours, &c.,

R. E. CROMPTON.

Arc Works, Chelmsford, December 31, 1888.

TECHNICAL EDUCATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask you to publish and invite criticism on the enclosed Bill, which has been read a first time in the "Kensington Parliament." It is put forward as not antagonistic to, but rather as including (see clause 8) the academic schemes of technical education with which we are familiar. I write as one who was at a primary school, who has worked at the bench, who has great reason to be grateful to the Science and Art Department, who has been a master at a public school, a manager of works, and an employer of labour.—Yours, &c.,

JOHN PERRY, M.E., D.Sc., F.R.S.,

"Vice-President of Council" (Kensington Parliament).

10, Penywern-road, South Kensington, S.W.

[The text of the Bill referred to will be found on another page.—*Ed. E.*]

PRIMARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: When I last addressed some observations to you on this subject it was with the object of maintaining that an ideally perfect battery, requiring no more attention than can be given to it by ordinary domestic servants, is peculiarly suitable for supplying electricity in houses of moderate dimensions, where not more than one, two or three electrical horse-power are required for lighting one, two or three dozen lamps. Some further experience has led me to the conclusion that batteries of greater power, capable of lighting groups or blocks of houses from small central stations, would be still more advantageous, for the following reasons:—

1st. Their control and management would no longer be left to the care of unskilled and often unwilling house servants.

2nd. The residual products—the acids as well as the dissolved zinc—would be concentrated in one spot, and in such quantities as to allow of their being collected and converted into valuable commercial products, which is quite possible.

3rd. The current discharged from such batteries is more economically produced, and more easily controlled, than with smaller batteries.

If, in elucidation of this third point, we compare three batteries each of which has an E.M.F. of 1·8 volt per cell, the first producing on short circuit a current of 6, the second a current of 60, and the third a current of 600 amperes, it will be seen that the internal resistance of the small battery will be $\frac{1\cdot8}{6}$, or ·3 ohm per cell, that of the next size $\frac{1\cdot8}{60}$, or ·03 ohm, and that of the largest $\frac{1\cdot8}{600}$, or ·003 ohm per cell. If the battery is composed of 40 cells, the internal resistance of the first will be 12 ohms, that of the second 1·2 ohm, and that of the largest only ·12 ohm.

This internal resistance in the first of the three batteries is equal to $\frac{1}{6}$th, in the second to $\frac{1}{60}$th, and in the third to $\frac{1}{600}$th of the E.M.F. of the battery on open circuit, and whereas the smallest of the three would be almost immediately thrown out of work by any alteration in the strength of the current, the largest of these batteries will have its E.M.F. so slightly affected by an increase or decrease of 10, 15, or 20 amperes, that any alteration may be easily counteracted by automatically switching one or two cells of the battery on or off as the E.M.F. falls or rises.

In other words, the larger the battery is the less will the intensity of the light be affected by alterations in the discharge, or in the number of the lamps required to be lighted by the current; and with the multiple cells there need be no difficulty in supplying current to hundreds or even thousands of lamps from central stations such as I have indicated, which, being noiseless, would be a great convenience in populous districts, as, for example, in the crowded streets of the City.

I believe it is not improbable that at least one such station will be established before very long.—Yours, &c.,

O. C. D. ROSS.

15, Relf-road, East Dulwich, December 24, 1888.

ALLEGED PIRACY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall esteem it a favour if you will allow me, through your columns, to enter my protest against the increasing practice of some electrical supply firms of appropriating other people's designs and ideas.

The case I wish more particularly to notice is that of a German firm in London who have just issued a new catalogue and price list, and have included therein, among many other designs, a system of theatre lighting and controlling patented by Mr. E. L. Berry and myself, without even the courtesy of requesting permission to do so, or mentioning whose arrangement it is. I may mention that we have the sole right to determine who shall manufacture and supply these goods.

I feel sure the majority of your readers will agree with me that this is not a legitimate way of soliciting business.—Yours, &c.,

S. SUDWORTH.

6, Estelle-road, Haverstock Hill, N.W., Jan. 2, 1889.

GLASGOW CITY HALL LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You noticed the official trial of this job in your issue of March 2nd, 1888. I send you a cutting from the *Glasgow Evening Times* of December 24th. For a wonder the critic is quite right. I can endorse all he says, and add more. It is simply painful to sit and watch the exhibition of "How not to do it." Bad carbons I should put down as the cause, from the flaming and sputtering. I have often seen steadier lights from the old Jablochkoff candles, with no pretence at regulation, let alone the old Brush lamp. The lights were bad—very. If the light cannot be improved I, for one, hope to see it out; but the lighting of the Glasgow Exhibition picture galleries was simply splendid by the same system.—Yours, &c.,

G. T. P.

PATENT RECORD.

PATENTS SEALED.

November 16, 1888.

12,437. R. E. B. CROMPTON and J. SWINBURNE. Chelmsford. Improvements in and connected with dynamo-electric machines. September 14, 1887.

12,830. W. R. LAKE. London. An improved regulating device for use in electric arc lamps and for other purposes (O. H. L. Lindemann, Germany). September 21, 1887.

12,924. G. ZANNI. London. Improvements in the manufacture of incandescent lamps, electric lamps, and of carbon rods therefor. September 23, 1887.

15,754. W. J. S. BARBER-STARKEY. Bridgnorth. Improvements in the electrolytes of secondary voltaic batteries. November 17, 1887.

18,030. L. C. E. LEBIEZ and P. L. VERCHÈRE. Paris. Improvements in thermo-electric batteries. November 8, 1887.

9,991. W. R. LAKE. London. Improvements in magneto-electric apparatus (W. Humans, United States). July 10, 1888.

10,954. E. H. GEIST. Cologne, Germany. Improvements in or connected with dynamo-electric machines. July 28, 1888.

11,338. L. KELNER. Brussels. Improvements in telephone line circuits. August 4, 1888.

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November 23, 1888.

12,418. S. Ziani de Ferranti. London. Improvements in conveying electric energy and in applying the same to the production of motive power. September 13, 1887.

12,419. S. Ziani de Ferranti. London. Improvements in electric railways. September 13, 1888.

13,561. H. W. Kolle. Tulse-hill. Improvements in electricity meters. October 6, 1887.

14,226. M. J. R. Jacquemier. Paris. Apparatus for measuring electric currents or electrical counter. October 19, 1887.

14,509. H. L. Callendar. University of Cambridge. Improvements in apparatus for measuring temperature on the absolute scale by means of change of electrical resistance. October 25, 1887.

15,939. W. Webster, Jun. Blackheath. Improved apparatus for the electrolytic treatment of sewage and other impure liquids. November 19, 1887.

16,087. J. S. Farmer. Salford. An electric contact maker, particularly applicable for use in conjunction with coin freed apparatus. November 23, 1887.

3,986. B. M. Drake and J. M. Gorham. London. An improvement in plates for secondary voltaic batteries. March 14, 1888.

5,586. H. H. Lake. London. Improvements relating to holders or supports for electric incandescent lamps, and to contact devices for use therein (C. Grivolas Fils, France). April 14, 1888.

11,403. H. H. Lake. London. Improvements in apparatus for the propulsion of vehicles by electricity (F. J. Weis, United States). August 7, 1888.

11,705. W. P. Thompson. Liverpool. Improvements in apparatus for measuring electric currents and recording the amount of electric energy consumed in a given circuit (Westinghouse Electric Company, United States). August 14, 1888.

November 30, 1888.

13,080. W. Fritsche. Berlin. Improvements in and relating to dynamo-electric machines. September 27, 1887.

15,385. E. Hermite, E. J. Paterson, and C. F. Cooper. London. Apparatus for disinfecting impure liquids by electrolytic action. November 10, 1887.

15,532. S. Joyce, Junior. London. Improvements in and relating to the use of electricity as a source of explosive power. November 14, 1887.

15,555. W. M. Mordey. London. Improvements in and pertaining to electric motors, and their application for charging secondary batteries or accumulators. November 14, 1887.

15,583. B. J. B. Mills. London. Improvements in electric tramways and railways (T. A. Edison, United States). November 14, 1887.

15,660. A. J. Thomas. Paris. Improvements in electric clocks. November 15, 1887.

15,801. W. H. Beck. London. Improvements in incandescent lamps (A. M. Michel, France). November 17, 1887.

16,305. A. C. Donovan and T. Weatherall. London. An improvement in voltaic cells. November 26, 1887.

16,458. A. A. Campbell Swinton. London. Improvements in electric telephones. November 30, 1887.

3,979. W. G. Johnson. London. Improved construction of plates and arrangement of fastenings for connecting them in voltaic order for medico-electric purposes. March 14, 1888.

6,075. E. E. Ries. United States. A new and improved method of utilising electricity for heating and lighting buildings, railway vehicles, and other places, and for operating breaks and signals on railway trains. April 24, 1888.

9,662. A. J. Boult. London. Improvements in or relating to electrical type-writers (J. F. McLaughlin, United States). July 3, 1888.

11,108. P. M. Justice. London. Improvements in electric conductors or cables, and in means for preventing disruptive discharges therefrom (E. G. Acheson, United States). July 31, 1888.

11,411. A. W. Meston. United States. Improvements in armatures for dynamo electric machines. August 7, 1888.

11,779. E. Emmanuel de Facieu. Burmah. Improvements in galvanometers. August 15, 1888.

SPECIFICATIONS PUBLISHED.

14,494, 1887. Spilker, W. Electrolysing chlorides, &c. (Price 8d.)

16,455, 1887. Thame, H. Secondary batteries. (Price 6d.)

16,537, 1887. Wynne, F. Application of electricity to propel vehicles. (Price 1s. 1d.)

17,585, 1887. Benardos, N. Electric regulators. (Price 6d.)

17,846, 1887. Anders, G. L., and others. Telephonic apparatus. (Price 6d.)

17,926, 1887. Hayne, W. E. Safety fuses for electrical circuits. (Price 8d.)

115, 1888. Baynes, S. W. Insulation of electric appliances. (Price 4d.)

569, 1888. Hedick, W. Recording and reproducing sounds and electric currents. (Price 11d.)

11,817, 1888. Hobbs, J. C. Electric furnaces. (Price 6d.)

11,890, 1888. Bonne, C. R. (Schaefer). Etching, &c., by galvanic action. (Price 4d.)

13,584, 1888. Meyer, E. Electrical tell-tales. (Price 6d.)

13,984, 1888. Mills, B. J. B. (Barbier). Electrical accumulators. (Price 8d.)

14,129, 1888. Lake, H. H. (Thomson). Dynamo-electric machines. (Price 8d.)

15,217, 1887. Lowrie, W., and others. Measuring alternating currents of electricity. (Price 8d.)

Reprint (with alterations).

13,533, 1887. Clark, A. M. (Gould). Electric railway signalling apparatus. (Price 8d.)

AMENDED SPECIFICATIONS.

14,983,* 1886. Serrell, E. W. Application of a solenoid for reinforcing electrical contacts. (Price 6d.)

2,128,* 1887. Higgins, F. H. W. Printing instruments for telegraphs. (Price 11d.)

TECHNICAL EDUCATION.

The following "Bill" has been forwarded to us for publication by Prof. Perry, who, as "Vice-President of the Council," has introduced the measure for discussion in the Kensington Parliament. It will be seen by his letter in our Correspondence columns that Prof. Perry invites criticism :—

In the Kensington Parliament, 1888.

A BILL FOR TECHNICAL INDUSTRIAL EDUCATION.

Preamble.

Whereas it is expedient to make provision for technical industrial education in England and Wales. Be it therefore enacted, &c. :—

1. This Bill may be cited as the Technical Education Bill, 1889, and shall not extend to Scotland or Ireland.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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2. "Apprentice" means any boy of less than eighteen, or any girl of less than seventeen years of age employed, whether under indentures or not, in any place which, under the Factories or Workshops Acts, is denominated a factory or workshop, or in any warehouse, shop, office, or other place of business, or for wages, or other remuneration, in any place of employment. But apprentice so defined shall not include any menial or domestic servant. "Master" means the employer of any apprentice as hereinbefore defined. "School Authority" means the School Board exercising jurisdiction in the district in which the place of employment is situated, or any elected body which may take over the powers of such School Board; and in places where there is no School Board, it means the county or borough council under the Local Government Act, 1888, or the Municipal Corporations Acts. "Technical education" is an education in the scientific and artistic principles which govern the ordinary operations in any industry. "Technical school" means a place for technical education, whether established and maintained: *a*. By the school authority, and open to all apprentices; *b*. By voluntary effort, and open to the apprentices of more than one master; *c*. Or by a master for his own apprentices. "Inspector" means the inspector of factories in whose district the place of employment is situated, or if there be no such inspector, then the School Board visitor for such district.

3. The Education Department shall forthwith and from time to time prescribe regulations in conformity with the rules for the time being of the Science and Art Department in the subjects in respect of which Parliamentary grants are made by the Science and Art Department, for the formation and instruction of classes of elementary school children who have passed the fourth standard, and thereupon the school authority may form such science and art classes, and provide such instruction accordingly, and earn such grants, and may assign such grants to the teachers of such classes, or may otherwise provide for their remuneration.

4. Every master shall provide each of his apprentices with technica education at a technical school.

5. Every apprentice shall devote at least two hours a day, five days in the week, during working hours, to study at a technical school.

6. The school authority shall annually in January prescribe the time for such study, having regard to the usual working hours in places of employment in their district, and shall publish a table of the times so prescribed. A printed copy of such table shall be conspicuously exhibited by the master in every such place of employment in such positions for such times and in such type and form as the school authority shall prescribe.

7. The school authority shall have power to establish and maintain such technical schools as may be necessary to accommodate and provide technical education for all apprentices in their district whose masters do not otherwise efficiently provide for the technical education of their apprentices. The master of each apprentice shall pay the prescribed fees for his tuition at such schools.

8. The technical schools established and maintained by the school authority may provide technical education for persons other than apprentices.

9. The course of studies at such schools, and fees payable for the same, shall be prescribed from time to time by the school authority, subject to the sanction of the Education Department.

10. The inspector shall inform himself as to the sufficiency of the technical education given to apprentices in his district, and report thereon to the school authority and the Education Department at such times and in such manner as they shall respectively prescribe. The duties, powers, and penalties relating to the office of inspector, specified in the Factory and Workshops Act, 1878, shall be applicable to any inspector under this Act, and to any place of employment within the provisions hereof. The inspectors shall be paid by the school authority such remuneration for their services under this Act as the Education Department shall approve.

11. All offences under this Act shall be prosecuted, and all fines under this Act shall be recovered on summary conviction before a Court of Summary Jurisdiction in manner provided by the Summary Jurisdiction Acts. The provisions of the Factory and Workshops Act, 1878, and the Acts amending the same as to legal proceedings and appeals, shall be deemed to be incorporated in, and made applicable to, this Act. The punishment for any offence under this Act shall be a fine not exceeding £5.

12. The expenses of carrying this Act into execution shall be defrayed by the school authority, who shall have power to provide for such expenditure by moneys raised, precepts issued, or rates levied under their powers. Separate statements of such expenditure shall be furnished annually to the Education Department.

THE EASTERN TELEGRAPH COMPANIES' EAST-END ANNUAL CONCERT AND DINNER.

The seventh annual Christmas Dinner Fund for the poor of the East-End of London, promoted by the staff of the Eastern Telegraph Companies, has this year been a great success. The sum collected amounted to over £120. Amongst the donors were the Lord Mayor, Sir John Pender, K.C.M.G., and Lady Pender, Sir James Anderson, Mr. J. Denison Pender and Mrs. Pender, Miss Pender, Mr. Lewis Wells, Mr. H. Saunders, Hon. A. G. Brodrick, Mr. W. Hibberdine, Mr. G. R. Neilson, Mr. F. E. Hesse, Mr. W. R. Lyne, Mr. J. G. Jack, Mr. E. A. Stuart, &c., &c.

The annual concert, in aid of the fund, was given in the Great Assembly Hall, on December 15th, and added about £40 to the fund. Among the artistes were Messrs. Guildford Dudley, W. J. Finnis, and W. H. Owen, who, as representatives of the Companies, acquitted themselves with remarkable ability. Mr. Arthur Briscoe again officiated at the organ and piano, and to him is due the great success of the musical part of the programme.

The distribution of the dinners took place on Christmas Eve at Mr. Charrington's great Assembly Hall, under the presidency of the Lord Mayor and Lady Mayoress in state. The Lord Mayor, who was most heartily received, gave a very practical speech, commenting on the different causes for the poverty and destitution amongst the masses of the metropolis, at the same time rejoicing that there were such agencies as his friend Mr. Charrington's work for the alleviation of much suffering. Mr. F. N. Charrington proposed a vote of thanks to the Lord Mayor and Lady Mayoress for their presence, which was seconded by Mr. Thos. Richardson, and carried by the thousands assembled with waving of handkerchiefs and much applause.—Mr. E. H. Kerwin, chairman of the Dinner Committee, made a statement showing that 425 families were benefited by the fund, representing some 1,800 persons. The materials for the dinners were then given out, and many a tear of joy was shed at the prospect of once more having a real good old Christmas dinner. The largest families received 7lb. beef, 3 loaves bread, 1½ quartern flour, 2lb. currants, 2lb. raisins, ½lb. suet, ½lb. mixed peel, packet of mixed spice, 2lb. sugar, ½lb. tea, with two oranges by way of dessert, and a small flag with which to decorate the plum pudding. Many a dark, sad East-End home has thus been made bright and cheerful this Christmas by the efforts of the staff of the associated companies.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 28th, 1888, amounted to £4,164.

MADRID TELEPHONE COMPANY (SOCIEDAD TELEFONOS DE MADRID). This company announces a distribution of an interim dividend of 10·75 pesetas, or 10 pesetas net. As the shares have 250 pesetas paid up, the distribution is equal to 4 per cent.

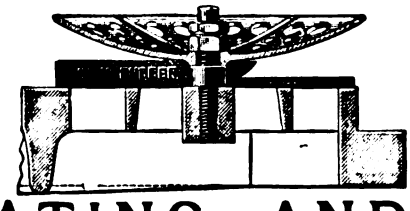
REUTER'S TELEGRAM COMPANY.—The Hon. Mark Francis Napier has accepted the vacant seat on the Board of this company.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 28th, 1883 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company), were £3,464.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The directors of this company have declared a dividend of 6s. per share for the half year ended December 31st, 1888, payable on the 7th inst.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1888.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Jan. 2, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Jan. 2, 1889.	
£			**TELEGRAPHS.**		£ s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	49 50	2 15 0	Jan., Apr., July, Oct.	...	...
2,614,820	Stock	15/0	Do. Preferred	81 82	3 7 1	" "	81⅞	79⅝
2,614,820	Stock	nil.	Do. Deferred	16⅝ 17¼	...	February	17 1/16	16½
130,000	£10	3/0	Brazilian Submarine xd	13¼ 13⅜	5 3 9	Mar., June, Oct., Dec.	13½	13¼
16,000	10	9/0	Cuba Submarine	14 14⅜	5 17 3	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18 19	5 5 3	" "	18¾	...
12,931	5	2/0	Direct Spanish (£4 paid)	4 4⅛	3 11 1	March & September	...	...
6,000	5	5/0	Do. Preference 10%	9 10	5 0 0	April and October	...	...
60,710	20	2/0	Direct United States	9⅜ 10	4 0 0	Jan., Apr., July, Oct.	9⅞	9⅜
380,000	10	2/6	Eastern	12⅛ 12¼	4 16 0	" "	12⅜	12 3/16
70,000	10	3/0	Do. 6 per Cent. Preference	14½ 15	4 0 0	" "	14¼	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	3 15 9	February & August	109	...
250,000	10	2/6	Eastern Extension	12⅝ 12⅞	5 1 0	Jan., Apr., July, Oct.	12 1/16	12⅝
22,050	10	8/3	German Union Telegraph and Trust	9 9½	7 7 4	January and March	...	...
179,177	10	1/0	Globe Telegraph and Trust	6⅞ 7⅛	5 5 3	Jan., Apr., July, Oct.	7 1/16	7
178,992	10	3/0	Do. 6 per Cent. Preference	14¼ 14½	4 2 9	" "	14 7/16	...
150,000	10	5/0	Great Northern xd	14¼ 14⅝	3 7 10	Jan., July, and April	15	...
17,000	25	12/6	Indo-European	38 40	6 5 0	April and October	...	...
38,348	10	2/6	London Platino Brazilian	7½ 8	...	May and November	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
338,225	Stock	13½%	Submarine	135 145	10 0 0	February & August	...	...
15,609	10	3/0	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98¼	97½
30,000	10	6/0	West Coast of America	9 9½	6 6 3	January and July	...	...
150,000	100	8%	Do. Debentures 8% xd	117 121	6 12 3	June and December	...	...
88,321	10	nil.	West India and Panama	1⅝ 1⅞	...	...	1⅞	...
31,563	10	12/0*	Do. 1st Preference 6%	11½ 11⅝	9 7 0	April and October	11⅝	11⅜
4,669	10	†	Do. 6 per Cent. 2nd Preference	11⅛ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	13⅜ 13⅝	...	March & September	13 9/16	13½
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 6	March & September	...	...
			TELEPHONES.					
224,350	14/0	5%	Consolidated Telephone and Maintenance	½ ⅝	6 0 0	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	1/16 1/16	...	...	...	...
80,000	5	5/0	United	13⅜ 14½	5 5 3	June and December	14⅛	14
55,000	5	4/6	United River Plate	5⅜ 5⅝	...	January and July	5½	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3⅜ 4¼	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4⅜ 5¼	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2 1/16	2⅛
312,000	½	5% '86	Maxim-Weston	1/16 1/16	...	February	...	...
			MISCELLANEOUS.					
87,350	12	36/0	Telegraph Construction and Maintenance	40½ 41½	5 15 6	March and July	41½	...
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17½ 18	5 11 3	February & August	18⅛	18

* Account arrears. † No dividend since May, 1880.

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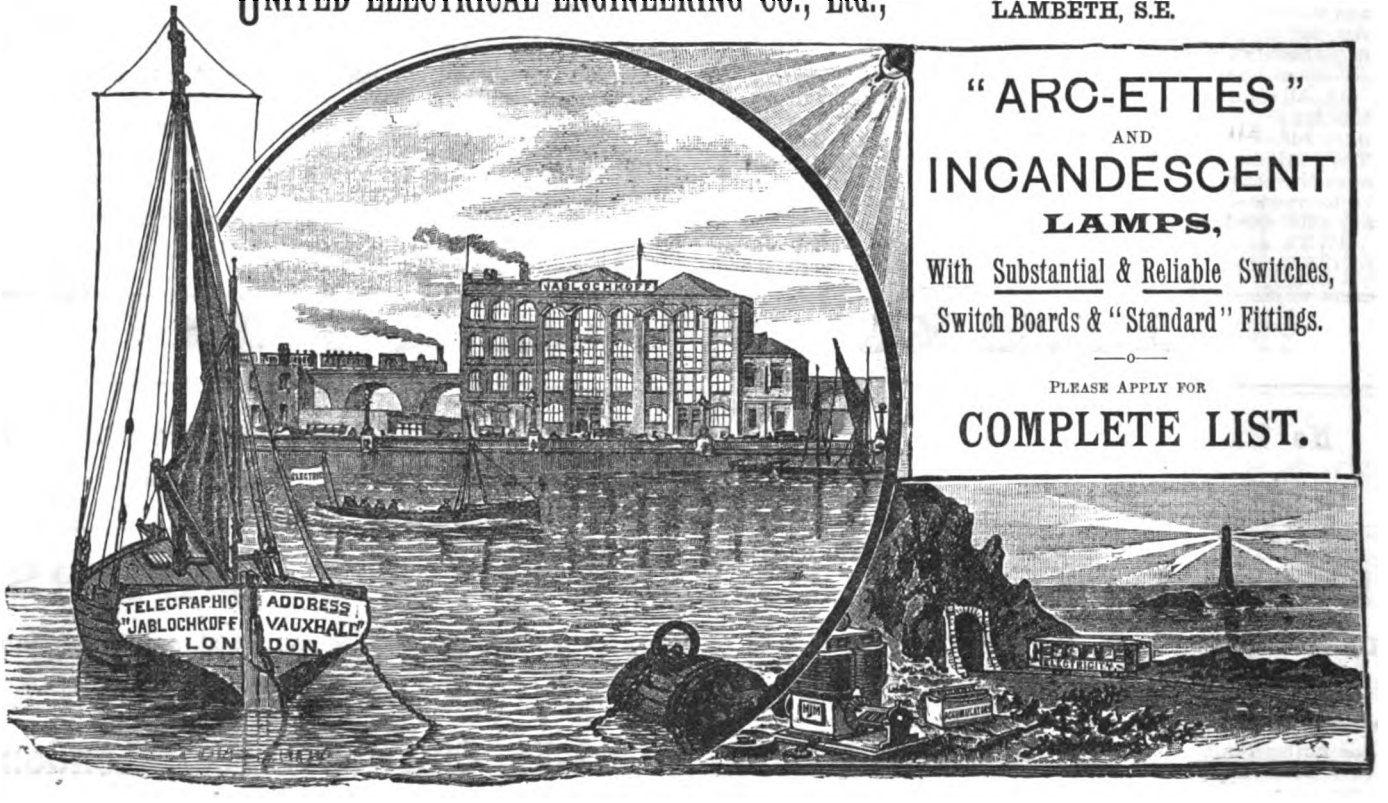

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THE ELECTRICIAN:

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NOTES.

The important question of electrical standards, and of providing facilities for standardizing instruments in practical use came before the Committee of the Electrical Trade Section of the London Chamber of Commerce on Monday last, when it was decided to request the Council of the Institution of Electrical Engineers to join with them in an endeavour to impress upon the Board of Trade the advisability of Government action in the matter. Our readers will scarcely fail to appreciate both the importance of the subject and the nature of the difficulties with which it is beset. Upon the accuracy or inaccuracy of a voltmeter the popular estimation of the success or failure of an installation to a not inconsiderable degree depends. If the instrument reads too high, people are disappointed with the light provided; if it read too low, they are still more disgusted at the bill for lamp renewals. Moreover, the percentage error which may be allowed without more or less serious consequence is very small indeed—certainly not more than one per cent. on either side. Yet we understand that Dr. Fleming, who has devoted an immense amount of time and trouble to this question, finds that errors of 5 and 6 per cent. are by no means uncommon in instruments ordinarily met with, whilst errors of even 8 per cent. have occasionally come under his notice. We are, however, glad to learn that the experience of testing a very large number of instruments enables Dr. Fleming to state that there has been a very marked improvement both in ammeters and voltmeters during the last two years.

As to the difficulties in the way of a practicable solution, these are chiefly of a financial character. The Committee of the Institution of Electrical Engineers, of which Mr. Preece is chairman, have been able to see their way quite clearly, so far as the technical and commercial details are concerned; but the question is how to meet the initial expense of providing a properly equipped laboratory. It is here that Government aid is sought. An allowance from the Government Grant Committee (from which, for instance, the Kew Observatory is assisted) would have the double advantage of supplying ways and means and placing the undertaking upon a recognised and authoritative basis. The suggestion now is to approach the Board of Trade upon the subject, and if they can be sufficiently impressed with its important bearing upon the public interest it is hoped that no great delay need occur before this much-needed reform is carried out. We may add that it is believed that the establishment would soon become self-supporting, the current cost being defrayed by the charges for re-calibration.

Another reform of almost equal importance with the foregoing was also discussed at the same meeting of the committee—that is the determination of a practical standard of light. The archaic device upon which the Government still insists is about as definite a standard as the dimensions of the proverbial lump of chalk, and would, doubtless, have been discarded long ago had any really satisfactory substitute at that time offered itself. That a satisfactory standard is now obtainable can scarcely be doubted after the unanimously favourable reports which have been rendered by the most competent and independent judges upon the pentane lamp of Mr. Vernon Harcourt. It is a little amusing to note, however, that the venerable wax candle "consuming 120 grains of spermaceti per hour" has still some firm adherents. At the Society of Arts last week Mr. Williams stoutly maintained that the wax candle was all that the most enlightened could desire, provided only that you took care that the top of the wick was bent in a graceful parobolic curve.

This is a subject which has long engaged attention both on scientific and on industrial grounds, and in any action that is taken by the electrical engineers it will be necessary to bear in mind that the gas interest is at least equally concerned. Mr. Preece, who was Chairman of one of the British Association committees appointed to consider the question, is of opinion that the candle should still be retained as the nominal unit, but that in practical photometry some more definite standard should be employed whose value should be interpreted in terms of the stardard candle. If we rightly understand Mr. Preece, this merely implies that the new standard should be adjusted as nearly as possible to the most probable true value of the old one, and that the term "candle" should be retained. With this we quite agree; but, on the other hand, we do not think that any attempt to compromise the question by introducing a secondary standard, to be compared from time to time with the old candle, would be at all satisfactory.

In connection with the interesting communications from Dr. Oliver Lodge on the electric dissipation of fog (in the correspondence columns of this and the previous issue) we may mention also some recent experiments of MM. Damon and Miquel

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DE RUI (*Revue Scientifique*). After repeating the original experiments of Dr. LODGE on the precipitation of tobacco smoke and of other fumes, they determined to see whether the same process would prove efficacious for the removal of bacteria from the atmosphere. The experiment met with a considerable degree of success. A measured quantity of air was first passed through a tube one metre long, open at both ends, and having a bulb of 5 centimetres diameter in the centre of its length; the number of bacteria contained in the bulb at the end of a certain interval was ascertained by well-known methods. A static discharge was now caused to take place within the bulb, whilst the experiment was repeated. The number of bacteria which had been retained was then found to have increased in the proportion of about 15 to 4. Other experiments followed, and in the end the authors sum up with due scientific caution as follows:—The only precise conclusion which can be drawn from these experiments is that within a certain space surrounding the poles the electric discharge produces an augmentation in the proportion of bacteria contained in the surrounding air. Without doubt also a certain number of them adhere to the poles themselves, as is the case when any kind of powder is so treated, and, as a consequence, the air is, to a certain extent, deprived of the bacteria which it first contained.

AMONGST other places where the local authorities are stirring in the matter of electric lighting is the town of Derby. Now, at Derby there is already in use a "refuse destructor," in which about 150 tons of *combustible* material (after excluding dust, &c.) are consumed weekly. Assuming that the heating power of this material is only one-third of what would be given by an equal quantity of steam-coal, we shall have a supply of fuel equivalent to 50 tons, or 112,000lb. of coal per week. At the rate of 3lb. of coal per horse-power per hour there is, therefore, an available fuel supply at Derby of 37,000 horse-power-hours, or, say, 220 horse-power continuously at work. It therefore seems highly probable that the Corporation of Derby could light by electricity at least the whole of the municipal buildings at a comparatively moderate cost. Doubtless there are many other places where the same considerations may be applied.

OWING to the American custom of quoting the price of arc lighting at so many cents per lamp per night, the cost is not readily compared with English practice, in which it is customary to quote per lamp per annum. It will therefore be interesting to give the figures for some of the chief cities of the States in the English form, and it will be seen that prices rule decidedly higher than with us. For instance, for a 10-ampere current, Boston pays no less than £47. 9s. per lamp per annum; Brooklyn, £40. 3s.; Philadelphia and Baltimore each pay £36. 10s.; and Buffalo, £32. 17s. In New York, where the competition was very severe last year, the price is at present only £25. 9s., but it is understood that the contract will not be renewed on these terms. The lowest charge on the list before us is at New Orleans, and amounts to £24. 16s., but this is probably for a 6-ampere current.

THE interesting letter of Prof. SILVANUS THOMPSON on the question of flashed filaments (in last week's *Electrician*) suggests one consideration which may tend to some extent to modify the conclusion arrived at. Prof. THOMPSON points out that the effect of flashing is to produce a filament, not of uniform resistance, but of uniform luminosity, and that this involves a greater deposition of carbon at the loop where the filament is subject to radiation from adjacent parts, and a lesser deposition near the clamps, where it is cooled by conduction. This is indisputably true, and it obviously tends to weaken the conductor where it should be mechanically strongest. But, on the other hand, does it not also follow that it is advantageous to the life of the lamp that the filament should be thickest where its temperature is liable to be highest, namely, at the bend? This consideration evidently applies chiefly to lamps with more than one turn in the loop, and it would, therefore, seem probable that for these lamps the advantage—other things being equal—lies on the side of flashed filaments.

FOR a rough approximation the candle-power of an incandescent lamp is often taken as varying as the fifth power of the E.M.F. at its terminals. In another column will be found a Paper showing that the candle-power can be very accurately determined from the current. The table we reprint shows an extremely close agreement between the "calculated" and "observed" columns; so close, indeed, that some captious critics might be disposed to inquire whether the photometrical observations were made before or after the calculation. Figures are very much like oysters, so much easier to swallow when raw than when otherwise. We should also like to know how the author determines "c_0." In the table we reprint, as in the others we do not, "c_0" is about one-third the current at normal candle-power. Now Weber has shown (*The Electrician*, Jan. 27th, 1888, p. 281) that a Siemens lamp taking ·5 A at normal candle-power begins to be visible at ·051 A. In fact, to obtain anything like such accurate results as those given, "c_0" as well as "a," must, we fancy, have been determined from observations with measurable candle-powers. Be this as it may, the law, if it is one, is both interesting and valuable, and we should be glad to hear what our lamp manufacturing experts have to say on the subject.

EVER since last July we have been saying what we could to dissuade investors from putting their money into Mrs. FRIEND'S sugar "shoot;" and in the month of September we did our best to cover the whole business with ridicule. The shares of the company went on rising nevertheless, until only a few days ago they reached six times their nominal value. Probably at this stage the gullibility of the public was exhausted, and then the astute widow, with her accomplices, calmly retired from business into the seclusion of the "Far West." The original capital was $1,000,000, in $100 shares, issued, however, at a very high premium; and taking subsequent transactions into account the total losses must amount to a very large figure. Who the real sufferers may be we have yet to learn; but we confess to feeling somewhat callous as to them in view of the fact that their folly has added one more disreputable scandal to the many burdens with which electrical industry has been saddled.

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NEEDLESS to say we should have much preferred to see our predictions and warnings falsified. They were based not on any knowledge of the alleged process—for that was kept dark from everybody—but on considerations which ought to have weighed with the simplest of grown-up children. Not to have patented a secret process was suspicious to begin with; to keep back all evidence of electricity taking any part in the process was still more so; and to put it on the English market instead of keeping it in America was a strong indication of bad faith from the very beginning. Other circumstances of a still more shady character connected with the antecedents of the inventor and the invention have since come to light, making it very hard for us to believe that the agents employed by Mrs. FRIEND were as innocent as they would have us believe them to be. The Americans have no high opinion of our business sagacity; but even Americans will prefer to think us knaves rather than credit us with such incredible stupidity as to have been really deceived by the unprofessional relict of the late "Professor" FRIEND. Query: *Is* he dead?

AN English financial journal largely responsible for the booming of this gigantic fraud now asserts that the "*bona fides* of the process remained unquestioned until last week." We suppose that is what the English promoters generally will say. But if this is their belief, it only makes their conduct the more reprehensible, for it amounts to a confession that they neither consulted electrical experts on the subject nor even took the trouble to see what the electrical journals were saying about it.

THERE was once a sensible newspaper man who put a dynamo into his cellar with a gas engine to drive it, and so lit up his office with the beautiful electric light. But twelve months later there came by that way a cunning central station man, and he said: "See, here is a transformer which I have made especially for you; put this in your cellar and you will have a better and a whiter light." So the newspaper man put away his dynamo and his gas engine, and now he says to his friends: "You should use the alternating current, because it gives a whiter light." But he is very angry with the lamp makers, who, it seems, have of late supplied him with a shockingly bad lot of lamps. Moral: Look after the volts, and the lamps will look after themselves.

Amsterdam.—The telephone between Amsterdam and Rotterdam will be opened shortly.

Edinburgh.—Mr. Richard Millar, of St. Enoch's-square, Glasgow, has been awarded the contract for the electric lighting of the Edinburgh Public Library.

Madras.—Extensive tramway schemes are contemplated in Madras, and it is possible that electrical power may be used. Nothing definite is, however, at present settled.

Military Telegraphs.—The *Wiener Tagblatt* states that the Russian fortresses in Poland are all about to be connected with one another by subterranean telegraph wires.

Malvern Link.—The Lighting Committee of the Local Board of Malvern Link have been instructed to ascertain and report upon the probable cost of electric lighting.

The Director General of Indian Telegraphs.—Sir Albert Leppoc Cappel, Director-General of Telegraphs, has been granted 15 months' extension of furlough, at the end of which he will retire.

Military Telephony.—It is reported that the experiments with portable telephones in outpost service during the last manœuvres were so successful that the War Office has ordered a considerable number.

Chiswick.—At the last meeting of the Chiswick Local Board the Clerk reported that the West Middlesex Electric Lighting Company had abandoned their intention to seek a provisional order, authorising them to supply electricity for the lighting of Chiswick.

Holborn Board of Works.—At a meeting of this Board on Monday last a letter was received from the London Electric Supply Corporation asking the Board's assent to the granting of a Provisional Order. The communication was referred to the Committee of Works for consideration and report.

The Govan Election.—Sir William Thomson spoke in support of Sir John Pender's candidature for the Govan division of Lanarkshire at a meeting held in Govan on Monday night. We notice, also, that one of the local journals reprints the biography of Sir John Pender from "The Electrician's Directory."

The Baudot Telegraph.—The Baudot duplex apparatus has now been working between Rome and Turin for some three months, this line being previously served by the Wheatstone. The Baudot quadruplex apparatus will start working on the Rome-Milan line, and perhaps also on the Rome-Naples line, in the course of the present month.

The "Manufacturer."—Judging by the special Christmas number of *The Manufacturer*, which lies before us, this paper certainly makes good its claim to be a representative newspaper of industries, trades, arts, manufactures, and inventions. *The Manufacturer* seems to us a most useful publication, both from the reader's and from the advertiser's point of view.

Pocket Telephone Directory.—The Northern District Telephone Company have just brought out a neat pocket directory, containing the names of the subscribers in the score of towns now served by their system. This little publication also contains details as to the charges for local and inter-urban messages, and a list of call offices open to the general public.

Transformers at the Brighton Central Station.—Mr. Arthur Wright, Managing Director and Electrician of the Brighton Electric Lighting Company, writes as follows:—"Will you kindly correct an item in the last issue, in which it is implied that we use exclusively Mordey alternating apparatus, whereas we have tried all forms viz., Kapp, Mordey, Lowrie-Hall, and lastly our own."

Election of County Councillors.—The Council of the London Chamber of Commerce at its last meeting decided to recommend to members the desirability of only supporting candidates for the London County Council on non-political grounds, and to urge them to give their votes to those possessing commercial experience, or known to be intimately acquainted with the interests and requirements of the business community of the City.

Armstrong's Improved Fastenings for Bolts and Nuts.—The Walsall Electrical Company have recently brought out an improved fastening for bolts and nuts, the special feature of which is a cap which falls over the nut, rendering rotation impossible. The arrangement is very simple and the additional cost is compensated for by the fact that frequent inspection and screwing up is avoided. The cap is also useful in protecting both the bolt and nut against corrosion.

St. Luke's Vestry.—At the last meeting of this Vestry a letter was read from Messrs. Deacon, Gibson and Medcalf, on behalf of the London Electric Supply Corporation and Electric Lighting Company, notifying their application to the Board of Trade for a provisional order to supply electric light in the parish of St. Luke's, and the asking the Vestry's consent to the proposal. The letter was referred to the Parliamentary Com-

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mittee. The Vestry at their former meeting were not opposed to the introduction of the electric light in the parish.

"Anti-Friction" Steam Packing.—We have received from Messrs. D. G. Cresswell and Son, of Bradford, a copy of their latest catalogue and price list. From the preface we gather that Messrs. Cresswell and Son have paid great attention to the manufacture of steam-packing, and now produce a packing which they claim will stand any pressure or degree of heat without altering its lubricity and elasticity. The catalogue also contains a long list of asbestos articles supplied by this firm, such as "asbestchouc" sheeting, asbestos cement, asbestos carbon for filters, &c.

An Electricity Counter.—We have recently had an electric counter, manufactured by A. Hubert, of Lausanne, brought under our notice. The apparatus is very simple and compact, consisting merely of a train of clockwork enclosed in a circular brass box. The clockwork is set in motion by the action of an electro-magnet, and the number of minutes, hours, tens of hours, and hundreds of hours the current is on is recorded on four small dials. The counter is one which would sometimes be of use on arc-lighting circuits, or in other cases where the energy supplied is constant in quantity.

Proposed Electric Lighting of Derby.—At the meeting of the Derby Town Council on Wednesday, the Mayor (Mr. Woodiwiss) mentioned that he had recently received communications from electricians submitting proposals for lighting the streets. He thought it would be best to refer the matter to the Parliamentary Committee for consideration, and moved accordingly. A brief discussion ensued, in which some members expressed the hope that the question would be fully looked into, and others were altogether hostile to the proposal, and objected to expenses being incurred. In the end the motion was approved.

Exports of Telegraphic Wires, &c.—The Board of Trade returns issued this week give the results for the last month of the year and for the twelve months. The following is a comparative statement of the exports of telegraphic wire and of apparatus connected therewith. The monthly details of former returns have been given in previous issues:—

	1886.	1887.	1888.
December	£42,349	£36,535	£33,707
Twelve months...	992,667	817,385	521,174

It will be observed that the unsatisfactory nature of last year's returns has been maintained up to the close.

The Commercial Cable Company.—The officers and staff of the Commercial Cable Company presented their president, Mr. J. W. Mackay, at Christmas time, with a handsome testimonial, which took the form of a silver centre-piece emblematical of cable enterprise. This presentation was especially made to commemorate the fourth anniversary of the opening of the cables, and was accompanied by an illuminated address. A few days previously, Mr. Mackay, who was staying at San Francisco, telegraphed to the General Manager at New York to the effect that he was not to forget the usual annual Christmas present to the cable staff of half a month's salary.

Messrs. Laing, Wharton and Down's Annual Supper of Employes.—The annual supper of Messrs. Laing, Wharton and Down's staff took place on Saturday, the 29th ultimo, at the Queen's Arms Hotel, Queen-street, E.C. An excellent repast was served up, after which the toast of "The Queen" was duly honoured. The continued prosperity of the firm was proposed by Mr. W. J. L. Sandy, and drunk with cheers. Mr. D. C. Bate, who presided, in conveying the thanks of Messrs. Laing, Wharton and Down to the whole staff for the way in which they had worked throughout the past year, took occasion to remark that contracts were on hand which would give full employment for several months, and that the prospects of electric lighting generally appeared more hopeful than had ever been. Other toasts, interspersed with songs, followed, and a most enjoyable evening was spent.

The Electric Light and Vision.—Dr. G. M. Gould, of Philadelphia, has written an interesting Paper, entitled "Is the Electric Light Injurious to the Eyes? (*Medical News*, December 8th) in which he sums up to the effect that this "light of the future" has not been proved to be injurious, except in the case of those "who approached it very closely, gazed at it protractedly, and without protecting coloured spectacles." There is no justification for the popular prejudice against the use of the diffused light as an illuminant. If, however, people will persist in examining the naked arc with the naked eye, it appears that the result "is characterised by temporary retinal paralysis, by blepharospasm, central scotomata, chromatopsia, &c., and is marked by intense photophobia, lacrymation, conjunctival congestion, &c. The attack usually lasts two or three days, the treatment being cocaine and atropine, and cold or hot compresses."

Electric Light Failures in Spanish Theatres.—Spanish advices state that on December 28 a special performance was to have been given in the Apollo Theatre, Madrid, but that it had to be abandoned owing to the failure of the electric light. Later advices state that the defects having been remedied, the Zarzuela Theatre was reopened, but that both it and the Apollo Theatre had to be closed again on the 2nd inst. The *Dia* says that the matter has been referred by the civil authorities to the consideration of the Theatrical Board, with a view to the presentation of a report upon the failure of the light, which is described as having not only prejudiced the companies, but, it is feared, has also been dangerous to the public. Nothing is said of the prejudicial effect of these avoidable difficulties upon the advancement of the electric lighting industry. It may be truly said of the electric light, both here and abroad, "Save me from my friends."

The Lighting of the City.—At the meeting of the City Sewers Commission held at the Guildhall on the 8th inst. the Chairman of the Streets Committee stated, in answer to a question, that the subject of electric lighting for the City had been under consideration for some time by the persons to whom it had been referred—namely, the engineer, the solicitor, and Mr. W. H. Preece. The engineer had done his part of the work, but some details remained to be settled between Mr. Preece and the solicitor. This settlement was, however, very near, and the Commission might expect a report at an early date.—Mr. Morton complained very strongly of this matter having, as he said, been played with far too long. There would be a new commission directly, and a fresh committee, who would, doubtless, feel it their duty to go into the matter from the beginning, at an enormous expense and a great loss of time. —We may add that the report furnished by Mr. Preece to Lieut.-Col. W. Haywood is of a confidential character.

Bath.—At a meeting of the surveying committee of the Town Council, held on Monday, 31st December, the following letter was read from Mr. H. St. John Winkworth, secretary of the House-to-House Electric Light Company (Limited):—"17, Bishopsgate-street Within, London. We beg to apply to your Corporation for their sanction to an application by this company to the Board of Trade for a license for seven years to supply electricity for lighting purposes, to be distributed by means of underground mains within your city. In making this application we beg to state that our company has just constructed the first central station in the metropolis for the accomplishment of distinct lighting throughout an extended area by means of underground mains under the superintendence of its founders, who in their Eastbourne institution enjoy the unique distinction of being the only engineers in the world who have so far accomplished this, and worked it uninterruptedly for the past six years." The matter was referred to the Electric Light Committee.

Caustic Potash and Bromine Elements.—According to Herr Koosen (Wiedemann's *Annalen*, Vol. XXXII., pp. 508-515), when caustic potash is employed in a Daniell cell instead of acid, its action is as follows:—1. KHO is decomposed, giving K, O and water. 2. K replaces zinc, forming sulphate of potash instead of sulphate of zinc. 3. Zn is oxidised by the liberated oxygen. 4. The zinc oxide thus formed is dissolved into the undecomposed KHO solution. Of these four reactions 1 diminishes the E.M.F., 2 and 3 strengthen it, as possibly does 4. The E.M.F. obtained in practice agrees well with theory. A Daniell cell made up with tolerably strong caustic potash remains very constant on a high external resistance. Caustic

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soda answers still better, as it dissolves the zinc oxide more freely. It is important to avoid diffusion as much as possible, and for this purpose Herr Koosen prefers to employ two porous pots, one inside the other, with the space between filled with a solution of sulphate of soda or potash respectively. He also mentions a zinco-bromide-platinum cell without porous pot which he has found to remain constant on closed circuit for months together; the bromine is covered with a layer of paraffin oil.

Christmas Festivities and the Electric Light.—At this season of the year the hospitals in the Metropolis are in the habit of giving entertainments to those who, perhaps unfortunately for the time being, are inmates thereof. To good work of this description the medical staff, nurses, students, and many of the outside public always lend a willing hand, and everything that adds to the attractiveness of the scene naturally helps to ensure the success of the undertaking. In this connection a novel feature was introduced into the entertainment given by the West London Hospital on the 2nd instant, when a large Christmas Tree was lighted by electricity, the form of lighting taking the shape of incandescent lamps interspersed amongst the foliage in a very effective manner. This work was carried out by the Woodhouse and Rawson Electric Manufacturing Company, whose premises are close by the hospital, at, it is needless to say, their own cost, and the whole work was completed in a remarkably short time. The artistic result was highly appreciated by the large company who had met to assist the secretary and staff in their pleasant task of endeavouring to alleviate in some degree the sufferings of their less fortunate fellow creatures, and in this they were evidently successful, as the patients appeared extremely gratified at the well-arranged programme provided for them, intermixed, as it was, with some excellent music.

Globular Lightning.—At the present time, when all questions connected with lightning are so much discussed, the following instances of globular discharges, which are said to have been observed at Hirschberg, in Silesia, during the storms of April 19th and 29th of last year, will prove of interest. During the first storm a woman and her son were looking out of two different windows of their house, when they noticed a yellowish ball of fire, about the size of a skittle-ball, moving slowly along the telegraph wires with a noise something like that of a flag rustling in the wind. After falling on to the grass-covered square the fire-ball again rose and disappeared rapidly over the roofs of the opposite houses in a S.S.W. direction. A similar phenomenon was observed by a woman who was looking out of a window facing the east. A fire-ball passed in front of the window from south to north, at a distance of some 20 metres; it then rose towards the roof of a house provided with a lightning conductor and disappeared, leaving no trace of its track. The ball was about the size of a child's head, of a yellowish colour, and no noise was heard. This ball is said to have been followed by a row of fire-balls about the size of billiard balls. The storm of the 29th April was extremely violent, and the lightning was of an extraordinary character. During the progress of the storm a brilliant globe of fire was seen to fall from a cloud upon Hirschberg, and to burst in mid-air. During the same storm a fire-ball was seen by a gardener at work in the garden of the Lycée, and by a young girl some 50 metres distant. According to the former, a reddish ball of fire came suddenly over the roof of the Lycée with a whistling noise, and exploded noiselessly over the trees in the garden, the fragments falling towards the earth in all directions without leaving any traces.

Electric Lighting in Kimberley.—The *Eastern Province Herald* of December 5th contains an interesting account of the flourishing condition of electric lighting in Kimberley. Some plant which had been unsatisfactorily tested in Port Elizabeth was purchased in 1884 by the municipality and removed to the Diamond Fields, Mr. Cousins being appointed as borough electrician. There are upwards of forty arc lights distributed through the main thoroughfares, which are connected with two dynamos. Mr. Cousins has since erected separate installations for the Queen's Theatre and Hershfield's bar, and for the shops of Messrs. Store Brothers. These are lighted by incandescent lamps only, except a solitary arc light in the front of the theatre. In 1866 the directors of the De Beers Mining Company determined to introduce the electric light, and two circuits were erected under the guidance of Mr. R. O. G. Drummond. Subsequently three other circuits were erected, and another is shortly to be commenced to light the underground workings. The engine, boiler, dynamo, and other accessories for this extension have been ordered from England. Up to the present date the wires from the dynamos to the extreme limits of the several circuits measure upwards of ten miles, and when everything is running there are 29 arc lamps of 1,000 candle-power each, 59 Bernstein lamps of 16 candle-power, and 24 Edison and Swan lamps of 16 and 8 candle-power. The engine house and dynamo rooms are constructed of galvanised iron. The engine is of 25 horse-power, furnished by Messrs. Marshall and Co., and is provided with Hartnell governors, sight-feed lubricators, and other latest improvements. In the room adjoining there are three Elwell-Parker dynamos, supplying ten arcs each; two Brush dynamos, supplying twenty arcs each; and a small supplementary dynamo, supplying the current to the incandescent lamps in the engine and dynamo rooms in the private dwelling-house of the resident electrician, and to eight accumulators. The circuits are arranged so that they can be run off any one of the machines, and they can also be all connected in series when necessary. Woodhouse and Rawson's magnetic cut-outs are used, and a switch is provided by which the wire circuits can be connected to earth in a moment in the event of a thunderstorm. The station is also well supplied with ammeters (Slatter's) and voltmeters (Cardew's). The Bernstein system appears to give every satisfaction, and is considered a great improvement upon the old system of incandescent lighting.

Electric Lighting in Birmingham.—The sub-committe of the General Purposes Committee of the Corporation which has this matter in hand met on the 3rd inst., and settled the recommendations on which its report to the General Purposes Committee will be founded. We understand, says the *Birmingham Post*, that several important amendments of the draft Provisional Order submitted by Messrs. Chamberlain and Hookham were agreed upon, affecting, amongst other things, the amount of capital required for the undertaking, and the formation of a company. These and other points, it is understood, will be discussed with the promoters before the report is formally prepared, and possibly an agreement may be arrived at. The report will then be discussed by the General Purposes Committee, and will be presented to the Council early in February, as the consent of the Council must be given in that month or the Provisional Order cannot be obtained next session, and the town will then have to wait for at least another year before any serious attempt is made to provide a system of electric lighting. The *Birmingham Gazette*, referring to the same subject, says:—Mr. Henry Lea, of the firm of Messrs. Henry Lea and Thornbury, consulting engineers, in a report to the Electric Lighting Sub-Committee, makes, we believe, the following recommendation:—"Overhead electric lines not to be employed within the borough of Birmingham, excepting with the special consent of the local authority, and then only for a short period, say for two years, in each case in which it may be desired to use them. They are to be employed only as pioneers for ascertaining the extent of the demand in new districts prior to laying down the electric lines permanently underground. The approval of the local authority to be necessary as to the method and details of construction and insulation of all overhead wires before they are proceeded with." After referring at some length to the arguments for and against the employment of overhead wires, the *Gazette* concludes its remarks as follows:—"These arguments, so far as they support the desirability of allowing a temporary use of overhead wires, seem to be well grounded. Of course all that is said about inconvenience to the electric lighting companies would go for nothing if the danger from overhead wire were as grave and pressing as the alarmists make out; but the evidence does not satisfy us that it is. On the contrary, the risk seems to have been exaggerated, and the public may therefore wait with comparative equanimity the probable decision of the committee in favour of the use of overhead wires for purely pioneer and experimental purposes."

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 245.)

§ 8. *Magnetic Screening and the Action of Metallic Masses in Induction Coils.*—If a primary and secondary coil are separated by a metallic sheet, Henry found* that a notable decrease took place in the intensity of the *shock* taken with this arrangement. A thick plate was found more effective than a thin one in thus preventing the inductive effect of the primary upon the secondary coil. If a slit was cut in a circular plate the annulling effect was altogether stopped. If the two edges of the gap (*see* Fig. 20) were furnished with wires leading to a magnetising spiral, Henry found he could in this way make evident the existence in the plate of a current induced by the action of the primary. A flat coil of insulated wire was substituted for the metal plate, and it was found that the screening action of this coil was only sensible when the two ends were joined so as to complete the circuit. This action, by which the induction of a primary coil on a secondary is prevented by the interposition of a metallic plate cylinder or closed circuit of insulated wire, is called *magnetic screening*. The elementary explanation of this effect is not difficult to arrive at. Suppose a small conducting circuit of resistance R to be placed in a magnetic field so that it is traversed normally by N lines of magnetic induction. Let the constant coefficient of self-induction be L. If, then, in any small time dt a variation of the lines of induction traversing this circuit takes, place the impressed electromotive force on that circuit will be represented by $-\frac{dN}{dt}$, and if at that instant the current in the circuit is i, by the principles laid down in the last chapter, the current equation will be

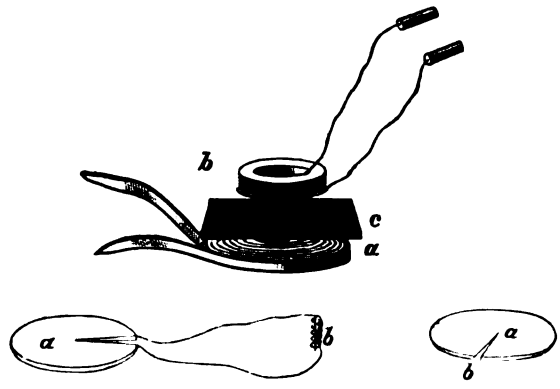

Fig. 20.

$$L\frac{di}{dt}+Ri=-\frac{dN}{dt}$$

or

$$\frac{d}{dt}\left(Li+N\right)+Ri=0.$$

Suppose the conductivity of this circuit to be perfect, and R therefore zero, we have, by integration of the above equation, the result

$$Li+N=\text{const.};$$

in other words, the lines of induction Li, added to the circuit by the induced current generated in it, are *opposite* in direction to those whose variation is producing it, and together with them make up a constant number. Hence, if the variation of N is such as to take lines of induction out of the circuit, the operation of the current thereby induced is to add or increase them in the circuit at an equal rate. If we suppose our circuit to be a perfectly conducting metal plate, and just behind this metal plate there is another small closed circuit, then any variation of lines of induction passing through this plate will not take effect in producing any induction current in the small circuit, because the operation of the current induced in the plate nullifies, as far as the small circuit is concerned, any variation of the external field. It is clear that these conclusions would apply to any surface of finite extent which possessed perfect conductivity; the induced currents which any variation of the external field would produce in this surface would always be such that the induction through each portion would be kept constant—in other words, that the perpendicular component of the magnetic induction at each point on the surface would retain a fixed value. It follows that a closed surface of zero resistance is a complete screen for all points in the interior against the effects of variation of the field on the other side of the surface; these effects reduce to the production of surface currents, which keep the field in the interior constant or at zero.

Faraday describes ("Exp. Researches," Vol. I., § 1720 *et seq.*) an experiment which at first sight seems to disprove the fact of magnetic screening. He placed a flat copper wire spiral, which was in connection with a battery and key, between two other flat spirals which were respectively connected with the two coils of a differential galvanometer. The coils were so joined up that the inductive effect of a break and make of the battery circuit produced no movement of the galvanometer needle because it was subjected to two equal and opposite impulses from the two coils. When an exact balance was obtained a flat plate of copper, nearly three-quarters of an inch thick, was interposed between the primary spiral and one of the secondaries. The galvanometer needle was not, however, any more affected than if the copper was away. To understand this we must bear in mind that the break or make of the primary current produces in the copper a secondary current, but as the effect of the primary coil on the secondary coil on that side is balanced by the other one we may regard the secondary coil next the copper plate as free to receive any inductive effect it can from the eddy current induced in the copper block. This secondary current induced in the copper generates a *tertiary* current in the secondary spiral, and this tertiary current consists, as we have seen, of a double short flux of electricity equal in quantity and opposite in sign. The galvanometer there is traversed by two equal small quantities of electricity in opposite directions, and as this does not sensibly affect a not very sensitive galvanometer no movement of the needle is seen. If, however, instead of the differential galvanometer Faraday had used a differential telephone he would have found distinct evidence of a screening action. Again, suppose that, instead of a simple make or break, Faraday had employed a steadily periodic or alternate current in the primary, this would have set up a steady periodic secondary current of equal frequency in the copper plate, and this again would have set up in the secondary coil on that side a steadily periodic tertiary current of equal period, and this might have been detected by the use of a differential electro-dynamometer or a soft iron needle galvanometer.

Henry found that a sheet of tinfoil afforded a very small amount of screening for shock, but a thick sheet of copper a very considerable one in the case of induction by battery currents, and in the case of induction by Leyden jar discharges the same phenomenon was apparent. In the case of an iron screen there is an additional effect, due to the fact that the iron, by its small magnetic resistance, conducts away the lines of induction somewhat through its mass, and prevents them from extending to the space on the other side. In this case also a considerable thickness of metal is necessary to bring about the effect of annulment. In the case of Sir W. Thomson's ironclad galvanometer a very thick shell of iron is necessary to annul all permanent field in the interior space. When we are limited to the use, as we are in practice, of materials whose conductivity is far from being perfect, it is found that a thin screen of metal hardly affords any sensible protection from inductive effect. In other words, the field on the other side of the screen is very far from constant.

(To be continued.)

* *Phil. Mag.*, Vol. XVI., 1840, p. 257.

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ELECTRIC LIGHTING IN THE CITY OF LA PLATA, SOUTH AMERICA.

BY W. R. CASSELS.

The story of the creation of the city of La Plata, the new capital of the province of Buenos Ayres in the Argentine Republic, reads like a chapter of romance. Five years ago the province of Buenos Ayres gave up its old capital to the nation and set out to found and build a new one for itself. All the energies and resources of the Government of this wealthy and prosperous province were brought to bear on the work, and in an incredibly short space of time a city of large area, with noble public buildings, elegant private residences, and spacious boulevards began to rise upon a site that until then had been open ground. Some idea of the babel of confusion that prevailed in the early days of the city may be formed when it is understood that the task was accomplished in the space of four years. Houses were springing up here and there isolatedly, but regular rows took long in forming. Immense piles of bricks and building materials lay scattered everywhere, and the streets were nothing but mud and ruts. At an early stage light was necessary and plenty of it, and the opportunity for introducing the electric light was still more favourable in view of the difficulties that were presented for the employment of the ordinary methods. Four towers, roughly constructed with the trunks of eucalyptus trees, were erected at a distance of several hundred yards apart, and arc lamps of 4,000 candle-power gave ample illumination to the busy scene. As the city progressed, and the buildings assumed proportions, and the streets became defined, the wooden structures were replaced by one central iron tower 150ft. high, and a few isolated lamps on poles.

So successful was this initiatory lighting found, and so well adapted to the peculiar conditions of the city, that after a careful study of the best form for its application, and of its cost as compared to that at which gas was offered, the authorities unhesitatingly decided that the electric light should be definitely adopted for the entire public illumination of the city. A contract was therefore entered into with Mr. W. R. Cassels for the establishment of 200 arc lamps of 2,000 candle-power each. The installation of these was completed in July, 1886; but so rapid had been the growth of the city that the number was now found insufficient. Meanwhile, however, a gas company had been organised, and a large gasometer erected by a syndicate of capitalists, who took the cities of London and Paris for their model, and hence were sceptical regarding the eventual progress of electricity. Strenuous efforts were made by them to obtain at least a part of the public lighting contract, and gas was offered of a better quality and at a lower price than it was supplied anywhere else in the country. Twelve months were allowed to pass by before a decision was taken. Political influences and personal interests were brought to bear on behalf of the gas, which had already been favoured by the previous Government with a grant of several acres of valuable land. The fight ran high and warm, but the true interests of the city prevailed, and the contract for electric lighting was finally doubled, and gas entirely excluded.

A short description of the present electric light installations at La Plata cannot fail to be of interest. La Plata is one of the few cities, perhaps the only one, the United States not excepted, that relies entirely upon electricity for the supply of public lighting on a large scale, and was not only the first city in South America to adopt the electric light, but even at the present day is, perhaps, the only example in the world where gas, although at hand, with an abundant and excellent supply, is not employed at all for street lighting. This result is in a great measure due to the fact that ever since its definite installation the electric light has given the most complete satisfaction, and with one solitary exception has never suffered an interruption. The exception was during a severe thunderstorm, before a system of lightning arresters had been applied, when several of the dynamos were injured by atmospheric discharges, and the light was extinguished for several hours. The plan upon which the city is built and laid out contributes also, no doubt, to the advantage of employing arc lamps and to the economy of the lighting. As is usual in all modern American cities and towns, the streets are all laid out in regular blocks with a frontage ranging from 85 to 130 yards, and one arc lamp placed upon a pole located at each intersection of the streets will illuminate equally down four different streets. If the city had been laid out especially with a view to its illumination by means of arc lamps it could scarcely have been improved upon. Each post is about 25ft. high, and the width of the streets admits of their being placed in the middle without interfering with the traffic; indeed in many cases the centre of the boulevards is occupied with a garden. Ordinary pine posts were used at first as a support for the lamps, but these are being replaced in the principal streets by iron structures. The cables are all overhead, and for the most part are carried on posts placed at the edges of the sidewalks. This method ensures safety, and greatly facilitates the maintenance of the circuits in good order. When the light was first laid down each lamp was enclosed in a lantern fitted with Trotter's dioptric glass, with the idea of softening the rays and counteracting the deep shadows; but since the public have become used to the light it is found that clear glass, or nearly clear glass, is preferred. La Plata suffers greatly from dust, which at certain seasons becomes most trying, and penetrates into every crevice even of the houses, and sweeps down in storms over the city in suffocating clouds. The arc lamps thus exposed must necessarily be of the simplest and least intricate construction, and the improved Brush type is found to answer very well—at all events, for the street lighting. The total number of arc lamps employed for the public service is at the present moment 258, and over one hundred additional lamps are furnished to private consumers, without speaking of the large number of incandescents. With the additions now contracted for and in process of being laid down the total number of arcs will be considerably over 500.

All the principal buildings use the electric light, among them the following, all supplied from the central station:—The two theatres, one bank, police building, the Legislative building, the Tribunals, the railway stations, all the principal shops and restaurants, the residence of the governor and other officials, and several private houses. Previous to the introduction of the more modern and perfect method of distribution, incandescent lamps were supplied in series and multiple-series from the arc circuits; but arc lamps were always supplied in preference when possible, several reception rooms in private residences, not to speak of billiard rooms and saloons, being thus illuminated. It has been noticed that familiarity with the electric light, and especially the arc light, created a demand on behalf of the public for more abundant artificial light than is usual, so that when gas is employed larger burners and more numerous are asked for. The inhabitants of La Plata when visiting other cities complain of the want of light. A fine is imposed by the municipal authorities for each lamp that becomes extinguished or operates in an unsatisfactory manner. It is interesting to know the number of fines thus imposed. In the year 1887 the average number of public arc lamps employed was 210, representing 75,600 distinct lightings of lamps during the year. Fines were imposed on only 156 of these, or less than ·02 per cent. The service in La Plata has been, in fact, more satisfactory and less subject to fine than any gas service in the other cities of the country. This regularity of service is greatly due to the method of running the circuits already described, but a complete system of watching and registering the behaviour of each lamp is kept up, and no sooner is a lamp reported as faulty than it is at once attended to. A complete record is thus maintained by the contractor of the nightly working of each lamp. Two watchmen on horseback parade the streets during the night, and their report serves as a guide to the day linesmen and trimmers for any work that may be needed. The unskilled labour employed consists of native and Italian "peones," who are found steady and faithful. One man can clean the glass and trim the carbons of forty to forty-five lamps in a day, which seems good work, as poles have to be climbed to get access to the lamp.

The adjoining plan shows the arrangement of the machinery in the station, of that part at least which has been in operation for some time past, and which relates to arc-lighting. The four engines are compound horizontal, each indicating 150

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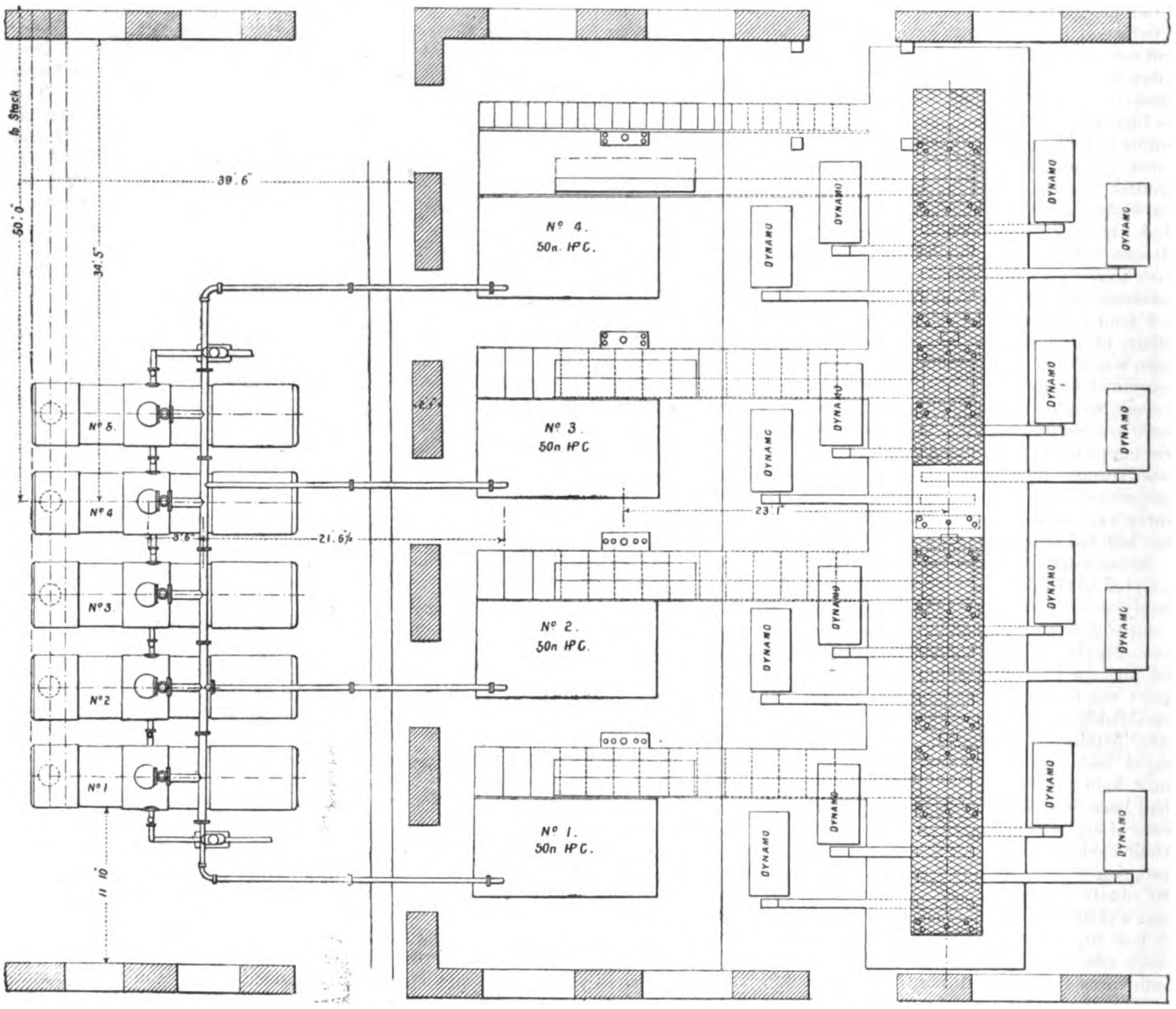
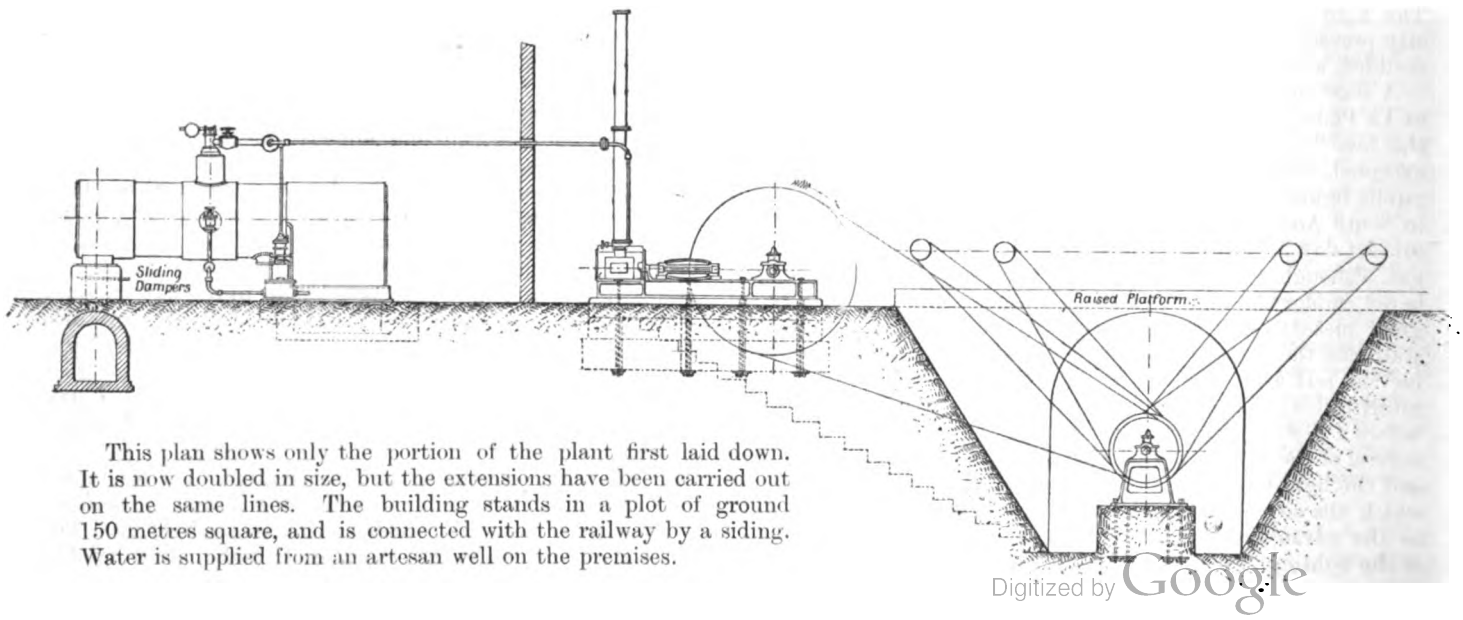
horse-power, supplied by Messrs. Davey, Paxman and Co., of Colchester. A main countershafting extends down the whole length of this part of the station, under the floor, and each engine is connected thereto with driving belts. On the fly-wheels of the engines is a loose pulley, or ring, and striking-out forks, worked by screw gear, are arranged to take off or put on any engine. All four engines are generally used to drive the countershafting up to midnight, when one is taken off. At





This plan shows only the portion of the plant first laid down. It is now doubled in size, but the extensions have been carried out on the same lines. The building stands in a plot of ground 150 metres square, and is connected with the railway by a siding. Water is supplied from an artesan well on the premises.

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any moment, as will be seen, however, any one of the engines can be stopped if required. By this method the work continues uninterrupted under all likely contingencies that may arise. Sixteen dynamos, some of 28-arc capacity, and some of 40, are placed in four rows down the room, and are driven from pulleys on the countershaft below. Two of these are in reserve, and can be switched into any circuit at a moment's notice. As a matter of fact it has been found that trouble or difficulty is more likely to arise from the engine side than from the dynamos, although either is a very rare occurrence.

Brush dynamos were originally laid down, and, generally speaking, this type has been adhered to. The original machines used in La Plata immediately after its founding some five years ago are still running in perfect condition, and have worked almost without any intermission every night since.

Coal, of course, is a very heavy item in that country, costing about 44s. per ton, and the water supply is not sufficient to admit of condensers. The average hours of running during the year 1887 for the street service was 11·54 per day, and according to the log kept the average consumption of coal in the same year was 3·05lb. per actual horse-power.

The success of this installation, from both a commercial and technical point of view, has been quite satisfactory. The contractors have been fully alive to the importance of avoiding anything approaching a failure, when this excellent opportunity of proving the value and efficiency of the electric light for street purposes was put into their hands, and they have now in consequence had other valuable contracts entrusted to them in South America. A great deal is due also to the enterprise and liberal spirit of the authorities in La Plata, who were bold enough to depart from the ordinary routine in contracting for the lighting of their city, and allowed electricity a fair opportunity of proving its worth.

REVIEWS.

Dynamo-Electric Machinery: A Manual for Students of Electro Technics. By Silvanus P. Thompson, D.Sc., B.A. Third Edition, Revised and Enlarged. (London: E. and F. Spon, 1888.)

There is no more distinctive note of the difference betwixt the technical journalism of Europe and of America than that of the relative standard of criticism which prevails on either side of the Atlantic. In America it is scarcely too much to say that technical criticism does not exist. A wide course of reading in Transatlantic periodical literature does not bring to our recollection a single instance of any other than indiscriminate eulogy of the products of native talent, whatever their intrinsic merit—a remark which applies both to the literary and the practical fields of labour. On this side of the ocean, and especially in our own country, it is the rule to attempt at least a more discriminative criticism. If a technical work be altogether worthless it seldom escapes a pronouncement of condemnation. The mediocre or merely respectable treatise may be passed over with a brief commendation, but a work of distinguished merit dealing with a subject of importance may confidently expect to receive an examination which, even if thoroughly appreciative—and *because* it is appreciative—yet seeks to discover in what particular room is still left for improvement.

So much by way of preface to a brief notice of the third edition of a work which beyond all dispute remains the only adequate and generally trustworthy manual on the subject of which it treats. The name of the author would alone be a sufficient guarantee that the volume is throughout informed with the scientific spirit, though, perhaps, the most noteworthy feature of this book (considering that it comes from the laboratory and not from the workshop) is the remarkable acquaintance with the minutiæ of practical detail which is so conspicuously exhibited. The book is one which no student of electrical engineering can at all afford to neglect, and it is also one which can scarcely be read without admiration for the extent and intimacy of the author's acquaintance, alike with the history, the practice, and the theory of his subject.

The important advance which the last two years has witnessed in our customary mode of regarding the phenomena of electro-magnetism had rendered it inevitable that the third edition of Dr. Thompson's work should differ very materially from that of 1886. It has become difficult to realise the fact that little more than two years ago the fundamental conception of the magnetic circuit, if not entirely unknown, certainly did not enter into the calculation of practical men; even transformers were then only beginning to be built with closed iron cores. The extensive change which has taken place in this direction has rendered necessary the addition of several chapters and the re-writing of others, and we now find a complete and lucid exposition of the magnetic circuit. The author, with characteristic industry, has also explored the history of the idea, and we learn, though without much surprise, that more or less explicit references to the general notion of the magnetic circuit are to be found in the writings of at least half a dozen of the early experimenters on magnetism.

Cumming, in 1821, talked of magnetic conductivity, but De la Rive seems to have been the first to employ the phrase "a closed magnetic circuit." The credit of having first perceived the importance of the conception in reference to the design of dynamos seems, however, properly to belong to Lord Elphinstone and Mr. Vincent (see *Proc.* Roy. Soc., XXIX., p. 292, 1879, and XXX., p. 287, 1880), whilst it is well known that the Brothers Hopkinson and Mr. Kapp were the first to formulate a quantitative treatment of the idea.

Speaking of the author's historical researches, we may add that a most valuable and comprehensive account of the early history of the dynamo has been appended to the introductory chapter. In this, as in other parts of the work, Dr. Thompson sets an example which is far too much neglected in the scientific literature of this country — that of quoting chapter and verse for his authorities. The introductory chapters have been re-written, the somewhat abrupt display of diagrams of typical machines which characterised the early pages of the former editions having now been avoided.

The description of dynamos of every imaginable design extends over seven chapters (five in the second edition), and contains more or less detailed reference to no less than 150 machines. It has evidently been the author's desire to confer immortality upon every individual who has been clever enough —or weak enough—to secure a patent for a dynamo of his own invention (?) This is very good-natured of Dr. Thompson, though we do not quite see what useful purpose it serves. A new and more extensive classification of machines has been adopted, as follows:—Closed coil type (*a*), ring armature dynamos (*b*), drum armature dynamos (*c*), disc armature dynamos, open-coil type, unipolar type, alternate current machines. In subsequent editions the last-named category will no doubt be sub-divided into machines (*a*) with and (*b*) without iron in the armature.

This section of the work contains a fund of detailed information of the greatest value. The only slip of any importance that we have noticed is in connection with the distribution of potential around the commutator: on page 68 the author says that in a well-arranged machine of the Gramme type the rise of potential from the negative to the positive brush should give when plotted a curve of sines. But on page 104, when speaking of the methods of obviating sparking, he dwells upon the importance of so shaping the pole-pieces as to obtain a uniform field immediately under either brush—which is of course the proper thing to do, although it is fatal to the preservation of the sinusoid.

There is, however, a graver question which we feel bound to raise at this point. In spite of all the information *about* the behaviour and construction of machines, we are disappointed to find that the author does not attempt to treat systematically of their design. It is true that some account is given of the methods of calculation introduced by Hopkinson and Kapp, but the author has not thought it necessary to shape them into a form which might have served for the direct guidance of the student in the design of dynamos and motors. We believe it to be true that this is a branch of the subject of which nothing approaching a competent knowledge can be gained without a good deal of practical experience. Still, we venture to think that the

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author might well have formulated the subject in such a way as to distinguish between what is known and can be imparted upon paper, and what must be sought for in experience. The method of procedure, in which is combined the outcome of the soundest scientific knowledge with the necessary degree of reliance upon the results of previous practice, might, at least, have been pointed out to the student with considerable advantage.

Turning to the chapter on the "Elementary Theory of the Dynamo," we find that Dr. Thompson has abandoned his $4\,n\,A\,H$ expression (where A was the equivalent effective area of the armature coil) for a fundamental equation of a somewhat more general character. We may mention in passing that an interesting application of the former expression is to be found in the Paper by Mr. Caldwell on the "Regulation of Dynamos by means of a Third Brush" (*Electrician*, December 28, 1888, p. 217). Dr. Thompson, however, now prefers to write

$$\text{(average)}\ E = n\,C\,N,$$

which is a modification of the form first introduced by Mr. Kapp, and in which n is the number of revolutions per second, C the number of conductors on the armature counted all round the periphery, and N the whole number of lines of magnetic force that traverse the armature core. Now, if we could only find out how to obtain the required value of N with the same degree of ease and certainty as the remaining terms in this expression, the practical design of dynamo machinery would be reduced to the utmost degree of simplicity; but unfortunately this is just what we can by no means accomplish, and, in fact, the whole question resolves itself into the attempt to determine beforehand by calculation what the actual value of N will be under the assumed conditions of construction. The problem is, in simple truth, incapable of anything more than a roughly approximate solution, except by reference to curves directly plotted from experiments carried out upon the iron carcase of the machine. Thus we are thrown back upon the method of Hopkinson, whose merit consists in the fact that it is independent of any assumed function of magnetisation, such as the tangent formula of Kapp (which in practice usually gives a characteristic which first rises too fast and then drops too rapidly), or even the "dia-critical" formula, which is favoured by the author. As for the latter formula—which was independently discovered by Drs. Thompson and Frölich—it is undeniably pretty, and has also the merit of simplicity; but since it involves at least two special experimental determinations, it cannot claim to be free from empiricism. We have not yet seen a curve plotted from this formula compared with the results of experiment.

Apart, however, from the question of designing, the treatment of the mathematical section is most instructive, and both the analytical and the graphical solutions are of the highest educational and elucidatory value. The combination of the two methods of investigation, instead of taking the analysis in one chapter and the curves in another, as in the previous editions, is a marked improvement.

Turning next to the chapter on "Alternate-Current Machines and Transformers," we find that the machines of Zipernowski, Westinghouse, Mordey, and others are now included, and the ingenious method of regulation introduced by Zipernowski is explained. The chapter on "The Elementary Theory of the Alternator" comes next in order, and although slightly enlarged from the previous edition, it cannot be said to do more than touch the fringe of the complex and difficult questions involved. In the present state of knowledge the data for a comprehensive treatment of the subject can scarcely be said to exist, but in future editions we may reasonably expect that it will receive much fuller consideration.

We may remark in passing that if the learned author can give us anything like a good working theory for the design of alternators, especially those with iron in the armature, he will have accomplished a task whose difficulty only those who have tried their hand at it are in a position to estimate.

The chapter on "Transformers" contains an excellent historical summary of the process of development which the induction coil has now undergone, and half-a-dozen of the best-known converters are illustrated and described. We are then introduced to the usual analytical investigation, which we take it is in this connection more than usually inadequate to represent the facts. We should have preferred to see the graphical constructions of Kapp and Blakesley, with such extensions as the ingenuity of the author would no doubt have suggested. The graphical method is not only capable of solving questions relating to transformers which are practically incapable of solution in any other way, but it has also the merit of displaying more fully the *modus operandi* of the several reactions involved. At the same time the student will obtain some insight into the general physical characteristics of the problem from a very excellent *résumé* to be found on pages 493-5. Unhappily, it must be confessed that at present no thoroughly satisfactory treatment of alternating-current problems is even imaginable. The assumption of a purely harmonic function for the current variation can only be justified as a first approximation, and under the actual conditions of practice it is probable that the rise and fall of the current waves is something very different indeed; especially when there is much iron enclosed by the circuit. In an ideal case an alternator intended for transformer service would be so designed as to give a curve of the most efficient shape under normal load. Happily, however, the efficiency of the transformer is in general so high that this refinement is probably quite superfluous. As to the efficiency of modern alternators little or nothing has yet transpired. The question is, however, one of considerable practical importance in view of the gigantic machines of this description which are now being built.

Six chapters are devoted to the electro-motor. This portion has been almost entirely re-written, much new matter has been added, and the mathematical treatment has been revised and curtailed. Upon the whole, and in spite of the skilful and ingenious manner in which many of the problems are dealt with, we do not find this portion of the work altogether satisfactory. Our objection is of a generic character. The subject is handled almost exclusively upon the basis of the laws of maximum efficiency and maximum output, which are ascribed to Jacobi and Siemens. The author is of course aware, and, indeed, he calls attention to the fact, that these are the laws of an ideal motor—a motor in which there are no losses other than those due to the resistance of the conductors, no Foucault currents, no hysteresis, no self-induction, and no mechanical friction. It may be, possibly it is, still useful to retain all that the author has elucidated concerning the behaviour of the ideal motor, but it would, we think, have been better to have incorporated some further account of the characteristics of existing machines, particularly in respect of the points in which they depart from the theoretical standard. As a simple matter of fact the work rendered by an electric motor is *not* represented by the product of the current and the *calculated* E.M.F., the latter being obtained by writing

$$E = \mathfrak{E} - i\,R,$$

where $\mathfrak{E}$ is the E.M.F. of supply, i the current, and R the resistance of the machine. Nor can the true value of E be obtained in any actual case save by the application of a brake-test. We can then write simply

$$E = \frac{W}{i},$$

where W is the power obtained expressed in watts. In a recent number of this journal (*The Electrician*, August 31, 1888, p. 522), Mr. A. T. Snell pointed out the utility of this method, and how by comparing this with the value previously written for E, we might discriminate betwixt the ohmic and the other losses, and so glean valuable information upon the merits of the design.

In fact, we think that a little consideration will show that an attempt to investigate motor problems upon the assumption that the useful work is equivalent to the product of the current and the calculated back E.M.F., is much the same thing as an attempt to find the E.M.F. of a dynamo by dividing the measured horse-power on the pulley (in watts) by the current. We expect that the worthlessness of any but dynamometer tests for motors will soon become an established article of the electrical engineer's creed.

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Since the theory of motors has been less widely studied than that of the dynamo, we may usefully proceed to a few more detailed criticisms. In the chapter upon the reaction between the armature and the field of the motor the author maintains his earlier views (in opposition to those of Profs. Ayrton and Perry) that the rules governing the construction of dynamos apply almost without change to motors. We take it, however, that either side is partly in the right and partly wrong. For shunt-wound machines of large size we should agree with the author, and for small, series-wound machines with his antagonists. Dr. Thompson very properly remarks that the elimination of eddy currents should be even more carefully attended to in the latter case, since, as was first pointed out by Mr. Mordey, the eddy currents in the armature core are assisted in the motor by the self-induction of its coils, while in a generator these inductions are mutually opposed. He also lays great stress on the fact that "the field-magnets must be made very powerful in proportion to the armature." Some definite illustrations from recent practice would have been useful here, and since none are given we may mention that in one of the best-known machines of modern design, the relative sections of the iron in armature and field is about 1:2 in machines of medium size. In these machines the lead is constant for all loads within the limit of the design, and there is practically no sparking. Taking this proposition as it stands, we find, however, that its consequences are elucidated by the author with his customary thoroughness and cogency. On page 567 we come across a statement which, although perfectly true in itself, should perhaps scarcely find a place under the heading of "General Expressions for Torque and Speed," since it can never apply to the important case of series motors. No doubt "if N be constant, the torque is simply proportional to the current in the armature;" but since N is constant only in case of a shunt motor supplied at constant difference of potential, the utility of the statement as a "general expression" is somewat dubious. The expression for speed in equation (γ) on page 568 might, we think, be made more clear by substituting the value of T, namely, $i_a \frac{CN}{2\pi}$ (where T is the torque, i_a the armature current, and C the number of turns of the conductor on the outside of the armature) the equation is

$$n = \frac{\mathfrak{E}}{CN} - \frac{2\pi T r}{C^2 N^2} \quad . \quad . \quad . \quad . \quad . \quad (\gamma)$$

where $\mathfrak{E}$ is the E.M.F. of supply, and n the speed; substituting the above values of T we get

$$n = \frac{\mathfrak{E}}{CN} - i_a \frac{r}{CN} = \frac{E}{CN},$$

where E is the counter E.M.F. This expression shows clearly that the speed of the motor depends on its own counter E.M.F. and not directly on the E.M.F. of supply, provided N be constant. The author, on the contrary, having apparently confined his attention to the (γ) equation and neglecting the second term, says that if N be constant the speed is proportional to $\mathfrak{E}$. It is true that these statements become practically identical if we are speaking only of a shunt-wound motor, with a low armature resistance, supplied at a constant E.M.F.; but as an expression of a general character the author's version is scarcely accurate.

Special attention should be directed to the mechanical characteristics (pp. 569-75) which serve to show with great distinctness the relations of E.M.F., current, speed and torque, which are not always clearly understood. The conditions of a shunt motor running under constant current might, perhaps, be stated with some additional clearness. The points of minimum and maximum torque should be clearly brought out. The maximum torque will obtain when the value of the product ($N i_a$) is a maximum at a certain critical speed, the latter varying for each motor. *Two* minimum or zero points occur when i_a and N are severally at their maxima—that is to say, first, when the motor is at rest and all the current is practically going through the armature; and, secondly, at its maximum speed, when the armature current is at a minimum.

There is a valuable chapter on the self-government of motors, which at the present moment involves problems almost as difficult as the self-government of the Hibernian race, although we are happy to believe that the former is nearer its realisation than the latter. The application of compound differential winding in the case of constant difference of potential results in a maximum value of N when the motor is running light, and the maximum rate of doing work (not torque) is obtained with a lower value of N. This method, though correct in theory, has some disadvantage in practice, as it involves a relatively heavy machine. We believe that the plan which has hitherto found most favour is to design the motor so that the output is greatest with maximum values of N and T. This involves series-winding and a variable strength of field, which may be attained with a centrifugal governor, cutting in or out some sections of the field windings. A motor of this description, built by Messrs. Immisch, was shown by Prof. Ayrton in his lecture on the Transmission of Energy, before the British Association at Bath (see *Electrician*, Sept. 14, 1888, p. 598); it is also in use in America. But, as the author remarks, this is not a faultless method, since obviously the speed cannot be quite constant. Perhaps for constant potential motors the best practical solution is given by a few series coils acting with the shunt winding. Such a machine is self-starting, and will run at fairly constant speed.

The concluding chapter on Testing Dynamos and Motors is excellent throughout; the chief novelty—and the only one which we have space to mention—is the suggestion (in p. 594) for examining the perfection of the magnetic circuit. The dynamo (or the motor driven as a dynamo) is run upon a suitable external resistance at a gradually increasing speed. The least speed of excitation is, *cæteris paribus*, a measure of the goodness of the magnetic circuit. The theory of this test is further developed in an Appendix, but we may add that in practice care should be taken that the external resistance is made about equal to the normal resistance of the circuit when the machine is taking its full load.

BOOKS, &c., RECEIVED.

Proceedings of the Canadian Institute. Vol. XXIV., No. 50 (Toronto: The Copp Clark Company.)

Transactions of the Royal Society of Victoria. Vol. I., Part 1. (Melbourne: Stillwell and Co.)

Twenty-fourth Annual Catalogue of the Officers and Students of the Massachusetts Institute of Technology, with a Statement of the Courses of Instruction and a List of the Alumni. (Boston.)

The American *Journal of Science*. Vol. XXXVII., No. 217. (Newhaven, Conn.; J. D. and E. S. Dana.)

"Contractors' Electrical Supplies." Second Edition, revised and enlarged. (The Woodhouse and Rawson Electric Supply Company, Limited. January, 1889.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, January 11th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. Paper to be read, "Refrigeration and the Artificial Production of Cold." By G. A. BECKS, Stud. Inst. C.E.

TUESDAY, January 15th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "The Compound Principle as applied to Locomotives." By EDGAR WORTHINGTON, B.Sc., Assoc. M. Inst. C.E. Discussion.

WEDNESDAY, January 16th.

ROYAL METEOROLOGICAL SOCIETY.

7:15 p.m. Annual General Meeting. Address by the PRESIDENT (Dr. W. Marcel, F.R.S.) on "Fogs." Reading of the Report of the Council and the Election of Officers and Council for the ensuing year.

CITY AND GUILDS OF LONDON INSTITUTE OLD STUDENTS' ASSOCIATION.

7:45 p.m. Meeting at the Central Institution, Exhibition-road. Paper to be read, "The Design of Electro-Motors." By ALBION T. SNELL, Member.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Channel Tunnel." By Col. HOZIER.

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CONTENTS OF THE CURRENT NUMBER.

Notes ... 267
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued ... 272
Electric Lighting in the City of La Plata, South America. By W. R. Cassels. Illustrated 273
Reviews ... 275
Meetings of Scientific Societies. 277
1888. Concluded ... 278
Electrical Aids to the Drama... 280
A 10,000-volt Transformer for Testing Insulation Resistance. Illustrated ... 281
The Bürgin Arc Lamp. Illus... 282
Incandescent Lamps: Candle-power and Current ... 282
Electrical Coal-cutting Machines 282
Proposed Electrical Exhibition in Birmingham ... 283
American Notes ... 283
Notes from Vienna ... 285
Correspondence—
The Dissipation of Fog.—Eric Stuart Bruce, M.A.... 285
Electrical Dissipation of Fog. Oliver J. Lodge ... 285
Electric Traction.—A. Reckenzaun ... 286
Primary Batteries for Large Currents. Illustrated.—N. G. Thompson ... 286
The Reckenzaun Storage Cell. Ch. Capito 286
The Application of the Projector in the Training of Heavy Guns.—Alfred E. Mavor 287
Electricity Meters.—John F. Forrest 287
Blondlot and Curie's Electrometer. Illustrated.—L. R. Wilberforce 287
The Electric Light at Galway. The Galway Electric Co... 288
The Invasion of Bath by the House-to-House Company. H. G. Massingham ... 288
Alleged Piracy.—G. Binswanger and Co. 288
Execution by Electricity. By Sydney F. Walker ... 288
The "Albion" Gas Engine. Illustrated 289
Patent Record ... 289
Companies' Meetings, &c.—
Metropolitan Electric Supply Company (Limited)... 291
Maxim-Weston Electric Co. (Limited) ... 291
Pilsen-Joel and General Electric Light Co. (Limited)... 292
New Companies Registered ... 293
City Notes, &c... 293
Companies' Share List ... 294

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1888.

(CONCLUDED.)

Telegraphs.—The traffic of the Post Office Telegraphs during the past year has maintained the steady rise which followed on the reduction of the rate in 1885; and there is now a prospect of not only recovering the loss of revenue consequent upon that reduction, but of meeting expenditure and interest on capital by current receipts, although not, perhaps, of overtaking the arrears which have accumulated from the time of the original purchase.

The following is a comparison of the gross revenue of the Telegraph service for the four quarters ended 1887 and 1888:—

	Mar. 31.	June 30.	Sept. 30.	Dec. 31.	Total.
1888 ...	480,000	480,000	565,000	515,000	...£2,040,000
1887 ...	445,000	465,000	540,000	465,000	...£1,915,000
Increase					£125,000

Partly because of the financial position of the service, but largely also because of the rise in the price of copper, the Department has made none but absolutely necessary extensions during the year, copper being the material which it is proposed in future to employ for all long circuits instead of galvanised iron. A perhaps not wholly regretable consequence of this check to the multiplication of wires has been the perfecting and extending the use of multiplex telegraph apparatus so as to force the constantly-increasing traffic through the existing system of conductors; and it is satisfactory to learn that the results foreshadowed by Mr. Preece, and noticed in our last year's review, have been fully borne out by the practical experience of 1888.

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CABLES.—Perhaps the most notable event of the year has been the nationalisation of the property of the SUBMARINE TELEGRAPH COMPANY, whose exclusive rights between the coasts of England, France, and Belgium are just on the point of extinction. We say nationalisation because it is not yet publicly known to which nation or nations conjointly the old company's cables have been transferred. This much, however, is clear, that the SUBMARINE TELEGRAPH COMPANY will cease operations at the end of next March, and that its cables will henceforward be worked under a friendly agreement by the several nations interested. Obviously the maintenance of these cables and the laying of fresh ones will fall upon the shoulders of the British Government, who will have a commanding influence, therefore, on their management and the rates which are to prevail over them. Already steps have been taken to introduce fast speed working over these lines connecting England with the Continent of Europe; and although the tariffs will not be lowered to any considerable extent in the first instance, the transmission of messages will be accelerated, with much advantage to the public.

Of the other submarine cables immediately connected with these shores we may note with satisfaction the cessation of hostilities between the several Atlantic Companies on the 1st of September last, when a joint-purse agreement was entered upon, based on a tariff of one shilling per word—just double the charge at which the companies had been ruinously competing for about two years previously. It is understood that the traffic has not materially fallen off under this increased rate, and that unless some fresh competitor enter the field the existing companies now in possession of the Atlantic may hope soon to recover a little of that financial prosperity to which their enterprise and perseverance entitle them; but it may still be doubted whether even a shilling tariff can be made remunerative over cables of such enormous length.

A cable has been projected, or rather threatened, connecting the West of Canada with the Australasian Colonies. The scheme, however, is as hazardous as it is—for the present, at all events—superfluous. If ever such an alternative route to the far East becomes necessary it will probably be undertaken by competent hands, not by the inexperienced and somewhat visionary advocates who at present have the scheme under their special patronage.

Of far greater practical import is the cable now about to be laid under the auspices of the EASTERN TELEGRAPH COMPANY on the West Coast of Africa, from Loando to the Cape. A girdle of electrical communication will then almost encircle the Dark Continent, and a choice of routes to one of England's most important naval stations will be established, as well as to commercial regions in the interior, the development of which will be greatly assisted by this improved means of communication.

It is understood that the section from Loando to Mossamedes, 700 miles in length, is being manufactured by the Silvertown Company, and that from Mossamedes to the Cape, 1,500 miles, by the TELEGRAPH CONSTRUCTION COMPANY. In this relation we may mention that the TELEGRAPH MANUFACTURING COMPANY, at their Helsby Works, have this year turned out nearly 7,500 miles of insulated wire, and upwards of 1,000 railway telegraph instruments, besides a considerable number for the Post Office.

Active preparations are being made by the EASTERN EXTENSION TELEGRAPH COMPANY for laying a third cable from Java to Australia, avoiding the volcanic route occupied by the two existing cables, and landing much further south on the West Australian coast. The length of this new cable, which is being manufactured by the TELEGRAPH CONSTRUCTION COMPANY, will be about 1,000 miles.

TELEPHONES.—Notwithstanding several incidents of an unsettling character which have occurred during the year, the telephone companies of England and Scotland, and to a less extent also of Ireland, have made very substantial progress, extending their trunk lines over considerable areas of the provinces, and completing their ramifications in the town districts. Never before, perhaps, have the companies shown such activity, or such a determination to firmly establish their hold on public confidence in the face of threatened trials. An attempt has even been made to bring about an amalgamation, and so to create a practically united and unassailable monopoly. As yet, however, the project seems to hang fire, whether owing to internal differences among the parties, or to legal difficulties raised by the POSTMASTER-GENERAL is not precisely known. One thing only is taken for granted, namely, that Mr. RAIKES regards these telephonic operations with apprehension and disfavour. In official quarters this is strenuously denied; but, on the other side, his public utterances are quoted as showing that he contemplates with some satisfaction the prospect of being able to dish the companies when their patents expire. A fairer interpretation perhaps would be that he means to negotiate with them in the interests of the public at large, and on more equal terms, when he is free to do so. Meanwhile, it must be confessed that no assistance from the Government has been given to the UNITED TELEPHONE COMPANY in promoting their long-delayed Bill for putting the question of overhead wires on a more intelligible legal basis. That Bill had to be again withdrawn early in the Session, owing to the action of local authorities, whose threatened opposition the Government took no pains to overcome. One result of this has been the abnormal activity to which we have made reference above, the companies making haste to cover the ground wherever the field shows promise of a future harvest. Happily the legal troubles of the telephone have begun and ended here, for in every one of its suits against intending competitors it has secured an easy triumph, its position being in no way disturbed in this country by the varying decisions respecting it in the High Courts of America.

Although not yet connected with the trunk wires of the provincial companies, the UNITED TELEPHONE COMPANY has reason to be satisfied with the patronage it has secured in the City and the suburban districts. A few figures will illustrate the progress made in the past twelve or fifteen months. In the month of September, 1887, the number of messages passed through the London Exchanges were at the rate of twenty-one million per annum. In the corresponding month of 1888 the rate amounted to twenty-two millions; whilst for the months of December in the corresponding years the messages were at the rate of twenty-five and thirty millions respectively. The main trunk line which this company is erecting to the north already covers about half the distance between London and Birmingham, and the ground is being surveyed for the erection of a similar line telephonically connecting the Metropolis with Bristol and South Wales

The last named district is already locally served by the WESTERN COUNTIES AND SOUTH WALES COMPANY, the extent of whose trunk line operations between such places as Bath, Gloucester, Newport, Cardiff, Swansea, Pontypridd, &c., may be judged from the fact that in the month of November last 30,028 conversations were recorded over these inter urban lines. The LANCASHIRE AND CHESHIRE TELEPHONE EXCHANGE COMPANY, which serves the district of which Liverpool and Birkenhead may be said to be the centre, has increased its trunk wire communication to 2,580 miles, the total mileage of the company's system at the end of September last being 8,930 miles. The revenue from the trunk wires and call offices of this company has just doubled in the last three years—that is to say, from £4,000 in 1885, it has reached £8,000 in 1888.

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There are 120 public call offices in this district, and between 40 and 50 towns connected by trunk wires. The charge for a conversation of three minutes' duration between persons in the same town is threepence; sixpence between persons in different towns situated in the Lancashire and Cheshire district; and one shilling when extended to the Yorkshire district of the National Telephone Company's system. Already these two companies are connected at many points, their respective subscribers being able to converse over the whole area covered by both. The National Telephone Company is the largest of the provincial companies, its district including a great part of Scotland, a portion of Ireland, the county of Yorkshire, and the Midland Counties. It possesses 126 exchanges—22 more than it had last year—and has established over 50 additional call offices, the total number being now 246. Its exchange lines number 8,607, and its private lines 1,331. A much smaller area is covered by the Northern District Telephone Company, but here again the same increasing activity is observable, its exchange subscribers having increased from 576 in 1887 to 805 in 1888, and its calls from 2,650 to 3,420 per day. The wire mileage belonging to this company is 2,660 miles, 1,430 of which are trunk lines, 800 for exchanges (18 in number), and 430 for private lines. It is estimated that the revenues of the three principal telephone companies referred to above for the year 1888 will be as follows:—The United £92,386, an increase of £2,431 on the previous year's receipts; the National £78,354, an increase of £10,902; the Cheshire £71,420, an increase of £5,626.

Coast Telegraphs.—We note with satisfaction the great progress made during the past year in bringing to an issue the important question of electrical coast defences. That part of the subject which relates to the safety of our mercantile marine in dangerous weather, and in case of shipwreck, is being experimentally dealt with at one or two points on the coast, and it is believed with encouraging results. When it is remembered how large is the proportion of disasters occurring to British vessels within about ten miles of the British coast, the importance of being able to command assistance from shore by telegraph or telephone established at suitably chosen light-vessels or light-houses beomes self-evident. Of, perhaps, equal concern to the nation is the protection of our shipping and ports from hostile incursions. The scheme which finds most favour, and which we understand originated with Mr. F. E. Baines, C.B., of the Post Office Telegraph Service, proposes to carry round the British Isles a line of telegraph following the coastguard path and connected at convenient points with the Postal Telegraph inland system. Proposals of this kind, which would admirably supplement the duties of the lightships' electrical systems, are, we believe, now before the Defence Committee, and are in a fair way for being, at all events partially, adopted.

Copper.—The gigantic operations of the Société des Métaux in copper have had a very disturbing effect upon the market. At the end of 1887 copper was quoted at £42 per ton; it now stands at £77. 12s., and has touched £80 during the year. The syndicate commenced operations by effecting a purchase of 42,000 tons of copper, representing practically the whole available stock, at a cost of nearly two millions sterling. It also entered into contracts to take the produce of copper mines all over the world to the extent of between 60,000 and 70,000 tons per annum, each mining company undertaking to limit its output to the average of the preceding three years. Of course this has had the effect of stimulating the activity of those producers who have continued to stand outside the ring, and many new or abandoned mines have been opened up. As the net result we find that the total imports of the metal during the first eleven months of the year amounted to 246,993 tons, or an increase of 68,918 on the previous year. When to this it is added that the actual consumption has necessarily been restricted by the rise in price, and that a lot of old metal has found its way into the market, it is evident that the stock in the hands of the syndicate at the present time must be huge. Rumour puts it as high as 150,000 tons. What will be the final outcome of this state of things it is impossible to say, but we see no immediate likelihood of a fall in price.

ELECTRICAL AIDS TO THE DRAMA.

The following interesting article, which we reprint from the *Scientific American*, will initiate our readers into some of the electrical devices which are employed with such striking effects upon the stage. We may add that several of the methods here described were used at the Lyceum during the performances of "Faust":—

The electrical sun is a big ground glass disc, with a voltaic arc lamp behind it of about 2,000 candle-power, connected with the street circuit. It shows through a hole cut into a drop curtain, and is set firmly in a frame covered with coloured gauze to represent the various hues with which it tinctures the atmosphere and the colours it projects upon the clouds during ascension and declination. One of the best effects yet had with this artificial sun is in Meyerbeer's "The Prophet," Act III., Scene I. The Anabaptists are encamped in a Westphalian forest near by a frozen lake that loses itself in the mist gathered at the horizon (also an electrical effect). The day is going down in the west with the sun. The fierce arc lights are moderated through a golden gauze, then softened by the ground glass outside.

As the sun is let down behind the paper mountains the purple and red gauze is pushed up over his face, and the lower clouds, now changed from cumulus to stratus, take on those horizontal lines of colour we know so well. "Tannhauser," Act III., Scene II., shows the mellow glowing of twilight, the masterful incandescent light, hooded in pale yellow, controlling the haze so well that in the expanse of mimic sky there is not a tint to dispel the illusion. The evening star in the south-west twinkles clearly like the ruby Mars. Wolfram, the minstrel knight, seems justified in his apostrophe:—

> "I look on thee, O star in heaven the fairest,
> Thy clear cut beam thro' trackless space thou bearest,
> The hour of darkness is by thee made bright,
> Thou lead'st us upward with kindly light."

This star consists of a single 16 candle-power incandescent light, connected with the street circuit, and affixed to a metal frame set in the drop curtain, only the star itself, with a covering of red gelatine tinctured with blue, showing through. In the duel scene in Gounod's "Faust," Act IV., Scene VII., will be found a striking electrical effect. As will be remembered, the soldier Valentine, brother to Marguerite, fights with Faust, the student and Marguerite's lover. As he is unfamiliar with the use of the sword, the Devil, in the guise of Mephistopheles, stands by, sword drawn, to aid him, interposing the weapon when Valentine makes too fiercely at the student. Heretofore, though there was a clash of swords, there was not here anything to indicate the possession of supernatural powers by Mephistopheles. The electric wires are connected with Valentine and Faust. The poles of the battery are connected under the stage with copper plates sunk into the flooring where the duel takes place. Copper nails driven, one into a shoe of Valentine, the other in that of Faust, connect up with the floor plates whenever they respectively stand upon them, and wires running up the legs and body of each and then down their several sleeves end in a small plug. So, when they draw their swords, they have but to insert these plugs into the holes sunk into their hilts and they are connected up with the electrical storage battery in the wings, Valentine representing the positive pole, and Faust the negative.

Every time Mephistopheles interposes his sword and strikes up the contending weapons, which are then brought in contact, the sparks fly furiously, and there are those weird, crackling, sizzling sounds heard in the lightning as well. When Valentine gets his death wound, he throws out the plug connecting his sword with the battery, by a simple turn of the thumb, and, as he falls, his sword flies from his hand with nothing to show the presence of any electrical connection.

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Everyone familiar with the charming music drama by Wagner, the "Ring of the Nibelung," will recall that impressive scene in the first act of Siegfried, where the stout lad Seigfried welds together the broken pieces of his dead father's sword which have been left him by his mother Sieglinda. The scene represents a cave in the rocks with openings into the forest. It is a smithy's forge, with fire, chimney, and bellows. The point of this scene lies in the prodigious strength of the lad Siegfried, who, because of it, succeeds where Mime, the smithy, has failed, and welds the terrible sword that is to kill the dragon who guards the treasure. The anvil upon which the lad strikes is connected by concealed wires with the storage battery, the positive plate being a corrugated piece of cast iron 6½in. by 12in., the negative pieces of iron wire three-sixteenths inch diameter and 12in. long, bowed upward at their centre and placed above and free of the corrugations below them. The current required being of 15 amperes, if the negative wire should rest upon the positive plate, a dead short circuit would be formed, and all metal connection with the battery would be fused; but bowed as they are, there is but a momentary short circuit at each stroke of the hammer, when the springy wires are forced down upon the under plate, producing only a shower of sparks, as if from the great force of the blows struck. At last, when the sword is completed, and a firm handle upon the hilt, he determines to test its temper, and raising it aloft brings it down with what seems a tremendous blow upon the anvil, which falls into two parts, as if cleft in twain, the sparks following the sword down to the ground. In reality he strikes a spring, which lets one-half the anvil fall, its under and outer side, as will be seen, having the corner cut off for the purpose and causing momentary short-circuiting.

A very pretty electrical effect is had in the garden scene in "Faust," Act III., Scene VI. Siebel, the would-be lover of Marguerite, advances to a bed of tulips, some red, some white, and some gold, to pluck a nosegay that he would leave upon her window to speak for him. Concealed in the corolla of each flower, or, rather, disguised as stamens and anthers, are two tiny incandescent lamps (15 volts each), the whorl of petals fresh and sparkling as when we see them fed with sunlight. Now, the demon Mephistopheles had long before warned Siebel—

"Every flower that you touch
Shall rot and shall wither."

Unheeding, Siebel picks a golden tulip, which shines yet as he lifts it up to him (the fine wire carrying the electrical current that keeps the bulbs in the flower aglow trailing after it, unseen amid the foliage). No sooner does he examine it, when, lo! Mephistopheles, partly concealed, raises his hand, the current from that single flame is cut off, and it grows dull and withers perceptibly. Siebel says—

"What, faded! Ah me!
Thus the Sorcerer foretold at the fair:
That, should I touch a blooming flower,
It shall wither.
But my hand in holy water I'll bathe—
See, now, will they wither?"

Here he plucks a red tulip, a white and a golden one, holding them up triumphantly, a rich, mellow glow in each (the electrical current following upward along the fine wire and the little bulbs yet lighted), for Mephistopheles may not raise his hand against the power of what has been blessed. Then he changes hands, and, like a flash, they fade, beaming with light again when he, remembering it was the other hand that touched the holy water, hands them back. (The operator, watching the scene, switches on or off as required.)

In the last act of Siegfried the wanderer (Wotan) is standing at the foot of a high cliff, with a deal of thunder and lightning overhead. He is armed with a great spear, steel-tipped and pronged, with the wood of it studded with steel. It is supposed to contain the sacred though unseen fire, and heretofore, until the present application of electricity, there was no evidence of it, save Wotan's word. He, as guardian of the rocks, is pacing up and down, with the spear in his hand. Siegfried comes seeking Brynhilda's rock. As Siegfried approaches he draws his sword, dealing a heavy blow against the spear of Wotan, while at the same moment a man in the wings turns an electric switch. The spear parts and from its shattered ends flames, like forked tongues, leap out. A lamp of 30 volts intensity is hidden in the spear; the core wrapped with heavy brown paper for insulation, with a mass of secondary cotton stuffed about the carbons at the point where the spear is to part. Then come thunder and lightning and black, rolling clouds, the last two projected upon the mimic sky by a stereopticon in the wings. The lightning and the clouds are scratched and painted on small bits of glass, before projection being greatly magnified by lensing, with a powerful voltaic arc electric light behind the condenser throwing them with wonderful precision and naturalness, the clouds rolling across an apparently immense expanse of sky, as the operator revolves the discs one over the other, and the forked lightning seeming to shoot across the heavens.

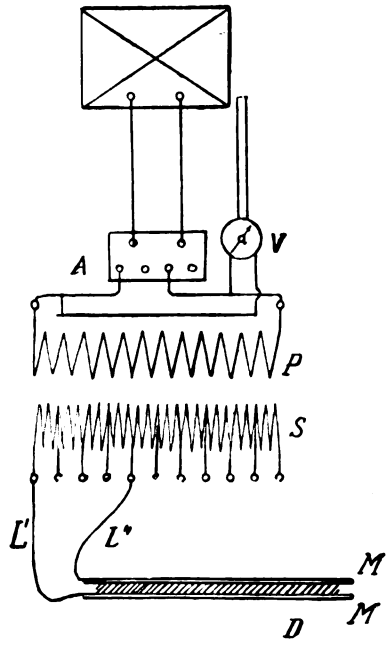
The realistic fire clouds and flames in the last act of the "Prophet," where the latter, learning he is betrayed, orders the firing of the Palace of Munster, are done by concentrating the arc light upon coloured gelatine, using first yellow for fumes, then yellow and white, then yellow and red, red and white, red and black. The snowstorm in "the Prophet" is made by forcing the light through white scratches on black glass. The sandstorm in the last act of the "Queen of Sheba" is done with yellow and black and pink gelatine before the light, and the rain by parallel scratches on a black surface, the arc light being dimmed and set aglow alternately, and the glass turned this way and that, so that the parallelism of the drops shall follow a supposititious changing of the direction of the wind.

The firefly is another fine effect, devised by the same hand as the others, and recently used at the Broadway Theatre, in the play of "The Kaffir Diamond." Tiny 15-volt incandescent bulbs were affixed to the weeds and rushes in a swamp, each bulb getting its life from a fine wire connected to an electrical accumulator in the wings. The operator in his hiding place, by pressing upon the knobs of his key-board alternately, lighting up one and then another, could make a single firefly appear to be darting hither and thither; then there would be two of them, a half-dozen, a score, or, pressing upon all, twenty-eight.

The artificial rainbow is made by the interposition of two triangular glass prisms, one elevated slightly over the other, before an electrical reflector, the bases and faces and lateral edges carefully adjusted with regard the one prism to the other. The electrical sun, set opposite to the point where the rainbow is to appear, is made, the better to aid the illusion, to shine into a mass of cloud, the rainbow seemingly only the reflection, refraction, and disintegration of sun rays into the various colours of the prismatic spectrum, the influence of the rain drops. So ingenious is the work that there is made to appear, as in nature, two arches, the primary with its inner circle of red, and the secondary with red along the inner.

A 10,000-VOLT TRANSFORMER FOR TESTING INSULATION RESISTANCE.

The ordinary tests of insulation, consisting only of a measurement of the insulation resistance, under the comparatively low



E.M.Fs. usually available, afford very little guarantee, especially in the case of electric light cables for the working strength of the insulation. It therefore seems very desirable to take advantage of the facilities afforded by alternating-currents to test such cables under much higher E.M.F.'s than they will be subjected to in practice.

At the "Menier" Electric Cable Works in Paris-Grenelle an alternating-current transformer, made by Messrs. Ganz and Co., of Budapest, has been used since March, 1888, for the purpose of testing cable insulation, or any other dielectric resistance. This transformer is constructed with a primary coil, P, for 100 volts and 70 amperes, and a secondary, S (*see* Fig.), for 10,000 volts and 0·07 amperes, the ratio of transformation being 1·100.

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The secondary coil is divided into ten divisions, the ends of which are led to metal contact pieces with conical holes. By means of two plugs and two flexible leads L'L", the dielectric to be tested can be subjected to a difference of potential of from 1,000 up to 10,000 volts, and its behaviour observed.

In the primary circuit there is, as well as the generator, a double-pole switch, A, in order to cut off the primary circuit entirely, before altering the secondary difference of potential by shifting plugs. A Cardew voltmeter is used for the control of the primary tension.

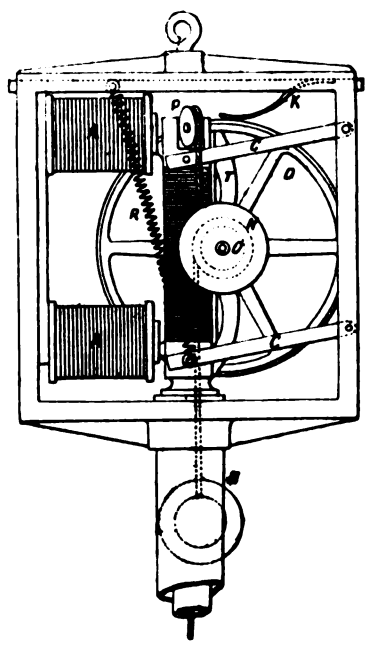
Concerning the construction of the transformer it may be mentioned that the primary and secondary coils, as well as the divisions of the secondary, are carefully insulated from one another with ebonite. The metal pieces forming the terminals of the secondary divisions are mounted on high ebonite supports, the metal plugs being also furnished with long handles of the same material.

The transformer, together with the terminals, is mounted on a strong base-board, on which there is also a double pole-switch with porcelain base and handle.

This method of testing the insulation of cables obviously affords a far better guarantee for their safe working in actual use than that of testing by measuring the insulation resistance with a comparatively low E.M.F., for it may happen that a layer of insulation which shows with only a few hundred volts an infinitely good resistance could be broken through by a few thousand volts.

THE BURGIN ARC LAMP.*

The two chief points in the mechanism of this ingenious lamp are the thick wire electro-magnet A, and the fine wire armature y. The



coils of A and y are wound so that the adjacent poles are of the same sign. The upper carbon-holder is suspended by means of a cord which passes round the pulley N, over the pulley P, and down the interior of the armature B, which is hollow throughout. A second cord, attached at one end to the ring M, and then wound round a drum which is fixed to the shaft O, serves to hoist up the upper carbon-holder when the carbons are burnt. When the current is switched on the armature is attracted by the electro-magnet. This attraction causes the arms c to move to the shaft O to lift; the arc is thus struck, and at the same moment the spring K is pressed against the wheel D. As the carbons are consumed the resistance of the arc increases, and more and more current goes through the shunt, until at last the repulsion between the poles of the armature and the magnet becomes great enough to force the armature slightly down. The wheel D is thus freed from the brake K, and the upper carbon-holder feeds down under the action of gravity. The moment this takes place, the whole system enters into a state of unstable equilibrium, resulting from the combined action of the brake K and the magnetic forces on the one hand, and of the spring R and the weight of the carbon-holder on the other. Owing to this condition of things the positive carbon feeds down slowly and continuously, and a satisfactorily steady arc is obtained.

* Translated from M. Hippolyte Fontaine's "Eclairage à l'Electricité," by kind permission of the author.

INCANDESCENT LAMPS: CANDLE-POWER AND CURRENT.

In the *Centralblatt für Elektrotechnik* Herr K. F. Slotte publishes a series of investigations to show that the candle-power of a glow lamp varies directly as the fourth power of the excess of current over that at which the lamp first begins to emit visible rays; that is

$$l = k\,(c - c_0)^4,$$

where k is a constant differing for every lamp, l the candle-power at current c, and c_0 the current at which visible rays first begin.

The following (shortened) table shows the results obtained with an 8 candle-power Edison lamp :—

EDISON LAMP, 8 candle-power. $k^{\frac{1}{4}} = 2{\cdot}707$, $c_0 = {\cdot}29$.

c	$l^{\frac{1}{4}}$ Calculated.	l. Observed.
·525	·64	·68
·610	·87	·87
·732	1·20	1·20
·842	1·49	1·48
—	—	1·68 = 8 c.-p (normal)
·990	1·89	1·91
1·23	2·54	2·54
1·29	2·71	2·66
1·32	2·79	2·66 = 60·1 c.-p.

Similar close agreement between the observed and calculated columns obtains also in the case of two Bernstein lamps, two Siemens, a Woodhouse and Rawson, and a Cruto. It will be noticed that the observed candle-power drops a little behind the calculated when the lamp is very much overrun. This occurs also in a 20 candle-power Bernstein, for which the author gives observations up to 480 candle-power, at which the lamp broke down, but up to 280 candle-power the agreement shown between the theory and experience is almost absolute.

ELECTRICAL COAL-CUTTING MACHINES.

The following is an extract from the Address of the President of the North of England Institute of Mining and Mechanical Engineers, delivered 8th December, 1888 :—"As bearing on accidents, coal-cutting by machinery is an important question, because of its effect on the number of men at the face of the workings. An engineering friend recently urged me to see Messrs. Bower and Co.'s electrical coal-cutting machine and electrical transmitters, and although your past president, Mr. John Daglish, in 1886 pointed out in his address several objections to electrical transmission, many of these have been surmounted, and others no doubt will be. I have therefore inspected the machinery, and have much pleasure in giving the following description, as a striking instance of the applicability of electric power in mines and collieries, and of its utility when the motor is to be moved about. This electric coal-cutting machinery is now being introduced by Messrs. W. T. Goolden and Co., of London, as licensees under the patents of Messrs. Bower, Blackburn and Mori, with further subsidiary patents. Messrs. Bower had for some years been experimenting on the use of coal-cutting machinery and had arrived at last at a form of machine which gave most satisfactory results, except in so far that, unless near the source of power, great difficulty was experienced in obtaining the necessary motive power. At last electricity was tried, and although considerable modifications have had to be made in the original method of application, by attention to every detail, very satisfactory results are now obtainable. This machine is only now being put into the market, as the makers have been anxious to discover every fault and overcome all difficulties practically before bringing it out seriously. The original machine was started in May, 1887, and is still running, doing very good work; although since then the machines have been completely remodelled and greatly strengthened. The machine consists of a frame travelling on wheels, carrying a specially designed electric motor, driving a shaft which carries the cutter attached by bolts to a coupling. This cutter consists of a bar carrying a series of star-shaped cutters, specially formed. The whole motor, and the shaft carrying the cutter bar, can be rotated in a horizontal plane, for the purpose of bringing the cutter in and out of the coal. The cutter is revolved by the electric motor at about 600 revolutions per minute, and the motor develops six to nine actual horse-power according to the hardness of the seam.

"The method of operating is thus. The motor is started, the turn-table is rotated by the worm wheel till the cutter has swept through a right angle, and is then 3 feet 6 inches deep in the coal. It is then drawn along the face by a winch, under or over-cutting the coal to that depth. The form of the cutter obviates the great

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difficulty usually met with in coal-cutters, viz., the jambing of the cutter by the falling coal, as in this case the cutter is always against the solid coal, and has never been known to be stopped when running by falling coal. The speed of cutting varies with the seam. These cutters have actually effected 45 yards per hour, including all stoppages, to put up props, &c., and in actual cutting time 30 yards have been cut in 36 minutes in hard dirt with pyrites and ironstone lumps. The advantages of the machine are obvious, the cutting can be carried on in any seam of dirt, thus saving coal. Only about 4in. of coal is removed. The coal is cleaner, and in larger pieces. A smaller length of face is required for a given output of coal, thus reducing bye-work, &c. The power is brought from a dynamo at the surface by two thin cables, whose position can be altered in a few minutes, as they can be rolled up and run out and hung on hooks like a piece of cord.

"Messrs. Bower's cost of holing by hand is about four times per yard more than by the machine. The difference in percentage of small is 10 per cent. in favour of the machine.

"The dynamo producing the electric current is situate preferably at the surface, and the power is led down the shaft by two small cables. Where wet or foul air is met with the lead-sheathed cables, manufactured by Messrs. J. Fowler and Co. (Limited), of Leeds, have proved very useful, and give very satisfactory results. The cables are then led along the road, either on insulators or fixed on a wood casing to the roof, or put on the floor. The cable in use at the actual face is a double insulated cable, both wires in one covering, being more convenient for handling. This is attached at any point of the main cable by screw connectors. The actual average engine-power required at the surface will be from 10 to 20 horse-power, according to circumstances, but it is well to run the dynamo from an engine capable of supplying, when necessary, considerably more, and the motor will then develop at times, for short intervals, more than three times its nominal power, enabling it to get through very hard pieces of stone or pyrites which occur in most seams.

"The machines are very strongly built, and designed with a view to being handled by non-technical persons, and all wire on the machine is enclosed in metal cases to avoid mechanical damage, and where necessary the whole of the revolving armature, and collector and brushes are enclosed in gas-tight casings. In addition to the original machine working at Messrs. Bower's collieries, these gentlemen have recently put down two more sets, and the machinery will be under trial at the pits of Messrs. H. Briggs, Son and Co., Normanton, and Messrs. Winn, Nostell, the latter part of this month.

"A new machine is now being worked out, which, employing the same principle of cutting, is adapted for the cutting of headings, either circular, or square, or rectangular."

PROPOSED ELECTRICAL EXHIBITION IN BIRMINGHAM.

We understand it is proposed to hold, towards the close of next summer, in Bingley Hall, a comprehensive exhibition on "popular" lines of electric lighting and electrical apparatus, assisted by industrial exhibits. The present expectation is that the exhibition will be opened about the second week in August, and will remain open during September and October. The main purpose of the exhibition will, of course, be to advance the application of the electric light, by illustrating its working and capabilities in a simple and effective way; but there can be no doubt that the enterprise is capable of being made a great centre of attraction. For example, it is proposed to illustrate the application of the electric light to coal-mines by constructing a miniature coal-pit in the hall. This task has been placed in the hands of an experienced colliery manager, and it is intended to make the imitation perfect in all material respects. There will also be band competitions and other extraneous attractions. In the electrical department of the exhibition the appliances and machinery shown will include dynamos, motors, alternate-current transformers, accumulators, and primary batteries, arc and incandescent lamps, carbons, insulated cables and wires, shades, fittings, &c. There will also be telegraph and telephone apparatus, phonographs, electric bells, and a complete display of electric lighting. Electrical motive power will be used for all working exhibits, and will be applied to all possible industrial purposes, including electric welding, smelting, electrotyping, &c. There will be an electric fountain. The industrial section will be extremely comprehensive, including steam, gas, and petroleum engines and boilers. The Executive Committee can be communicated with as to further particulars at the County Chambers, Corporation-street. We believe an effort is being made to procure the services of the Prince of Wales for the opening ceremony. The net profits of the exhibition are to be divided between the Queen's, General, and Jaffray Suburban Hospitals.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *December 29th*, 1888.

In my last letter I made a brief reference to the earnings and dividends of the Western Union Telegraph Company and the American Bell Telephone Company, the figures proving that both corporations were in excellent financial condition; and it may, perhaps, be worth while to supplement the figures by others which go to show how large is the number of those who are interested as stockholders in these corporations. The general idea is that each of them is a gigantic monopoly, operated for the sole benefit of one or two men. It is curious to observe, therefore, that the Western Union Company has no fewer than 32,000 stockholders, and the American Bell Telephone Company about 1,800. Monopolies which are split up in the hands of nearly 35,000 stockholders would hardly seem to deserve the opprobrious name; and the fact reminds us that in talking of monopolies we must get our ideas adjusted to nineteenth century conditions, under which the owners of a property to which the name of monopoly may be applied number by the thousand, and are, in a word, as numerous as the *employés* of the concern. Incidentally, it may be remarked that a company with as many as 32,000 stockholders on its books must have no small amount of ledger work on that account.

Speaking of the position of the Western Union Company with regard to the public reminds me of the figures which Mr. W. B. Somerville, of that company, connected with the Associated Press, has recently given, as representing the amount of work done for the newspapers. It is very often argued that the telegraph, after all, is not a universal convenience in the way that the postal service is; and here this is taken as one of the reasons why the Government should not have control of the telegraphs. There is some warrant for this view of the case, but at the same time it is to be remembered that through the newspapers the telegraph does become a public convenience and necessity of the first order. In America, as in England, the newspapers are very largely made up of telegraphic despatches, deprived of which the papers would lose much of their interest and value. It is remarkable how, when there is an interruption of cable or telegraphic service, and the newspapers are limited to local news, the horizon closes in upon one, and life seems to lose half its expansiveness and the broad human interest that gives it its charm to a modern. The appreciation of the American newspapers of the worth of telegraphic news is shown in Mr. Somerville's statement that the American newspaper press this last year took about 184,000,000 words of special matter, while the Associated Press sent 327,000,000 more words over its wires. This does not exhaust the figures, however, as there are other press agencies at work in this field. A newspaper has been known to have received 35,000 words of telegraphic matter in a single night, and one of the Western papers is said to have paid over $100,000 for one year's despatches. It may be noted that this matter is almost wholly of the class known as "news"—that is to say, it does not include, as it would in England, frequent and copious reports of political meetings, with Mr. Gladstone or Lord Salisbury at full length. While as a people we are credited with an immense appreciation of oratory, it is a remarkable fact that one very rarely sees a political speech reported in its entirety. Whether this implies a lack of merit in the speeches or an actual distaste for Parliamentary eloquence on the part of the people I will let your readers conjecture. Mr. Somerville, in regard to the cheapness of the service and the encouragement thus given the papers to use the wires, says that the general average rate per word over the country is only from ⅛ to ¼ per cent. per word. It is, of course, this cheapness which has stimulated the growth of the system, for less than fifteen years ago the whole amount of special telegraphic matter taken by American newspapers was only 30 million words.

I made brief reference last week to the movement which was on foot, and the plans which it is understood have practically been

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consummated, for the combination of all the parent Edison interests in one grand corporation. The capital of the new company is stated at $12,000,000, and Mr. H. Villard, at the head of a number of German capitalists, will put the thing through. The matter attracts a great deal of interest and attention in electrical circles, and is generally regarded as a good sign of the confidence that is now felt in the stability of electric lighting enterprises. There has been a belief in some quarters that the scheme would be extended so as to include the Westinghouse interests in the arrangement, but so far no definite plan of the kind has been discovered; on the other hand, it has been strongly repudiated by both parties.

With regard to the combination of conflicting interests, the *Western Electrician* takes occasion, in a recent issue, to make extended editorial comment on a passage in one of my letters in which I spoke of the rupture between the Westinghouse and Thomson-Houston Companies. In respect to the wider combination, to effect which strong efforts have certainly been made, the paper in question says: "From all present indications the formation of such a trust, which has from the beginning seemed to many impracticable and improbable, is relegated still further to the future, if, indeed, it is ever to materialise." Occasion is taken at the same time to point out that a more practicable plan would be a working arrangement between different manufacturing companies by which they would agree not to sell arc or incandescent apparatus below a certain price per light, and not to intrude into territory already occupied by another company. This is a good suggestion, and if it could be carried out would undoubtedly, in a great many respects, tend to improve and strengthen the business. The trouble is, of course, that through the weakness of human nature, and the outcropping of original depravity, it is generally found pretty hard to get all the parties to live up to their agreement. Our railroads, for example, are always making new deals as to traffic, and then complaining that each other is cutting rates; and it is to be feared that a little similar experience might be had in the electric light field. Then, again, where a company has gone into a town and established a lighting system, and got it upon a good paying basis with local capital, it does seem unfair that another company should come along and break the business up, simply for the sake of getting a foothold. But the difficulty that arises here under a territorial agreement is to determine when that territory has really been developed to its fullest extent. I know of several instances where, to all appearances, the field was pretty well occupied, and the company in possession was doing a good steady business. Another company, enterprising and bustling, comes along, and starts a second local lighting system, and the result is that inside of a year or two the business in the same place has been increased 300 or 400 per cent., and both plants are doing well. On the other hand, there are cases not far to seek where the incursion of a second company has been disastrous to all concerned, so that capital has been rendered timid with regard to this new field for investment. Although it is hard to tell when a town or city has all the electric lights it can find room for, it would always be safe to say that when the competing companies got down to the point where they sold their lights for less than it cost to give the service they had reached a point at which they had better not do business. I do not know whether this question has come up at all in England yet, but here, in America, it has very often been a vital one.

Owing to the large use of copper in electrical industries the course of the copper market is watched with a great deal of anxiety. Of late there has been some hope that prices would fall, and that the French Syndicate which has been manipulating the market would go to pieces. The delay in announcing the revised contract between the syndicate and our American copper companies led to the belief that the whole scheme might fall through, and that the market would settle back to its former condition. It now appears, however, that under the new arrangement there will be little hope for the consumer, and that in all probability prices may be screwed up another peg or two. It is said that under the new arrangement the companies will have a fixed net price for their copper on delivery, and will not have to wait for its sale in order to get a share in the profits. By this arrangement, it is said, the great Calumet, Hecla, and Tamarack Mines will realise a profit of no less than 4d. per pound on their product.

Old as the primary battery is, and vast as has been the work done in connection with it, there seems to be plenty of room for experiment and improvement. One of the recent departures made in this field worthy of note is that of Messrs. I. L. Roberts and H. L. Brevoort, of this city. Mr. Roberts has been an indefatigable investigator for a great many years, and has produced a number of interesting and useful types. In the present instance he and his associate went to work with the intention of obtaining a partition between the two liquids in a battery, which, while having electrolytic properties, should be non-porous; so that, whether the battery was on open circuit or closed, there would be no intermingling of the liquids on either side of the partition, and yet, when the circuit was closed, the battery would give its current freely, chemical action taking place through the partition. Their experiments in this direction have been going on for at least two or three years, and large varieties of materials have been tried. In the latest and more perfect forms of their battery the inventors employ mineral substances of a gelatinous nature. Thus, for example, they use the gelatinous silicate of soda, with which they impregnate the ordinary porous cup. Under these conditions the partition is practically impervious to liquids; yet, at the same time, serves the purpose for electrolytic action, and undergoes such changes as are necessary to the transmission of electric force or current. As the inventors put it, they have in their partition combined in one substance the solid properties of a porous earthenware cup and the electrolytic properties of the liquids, so that they have made the electrolytes solid and the partition electrolytic. The results obtained with this form of battery are said to be very satisfactory, so that they get a much larger proportion of the theoretical energy of the zinc, as current for working in the external circuit, due to the absence of local action, even when the cells remain idle for long periods of time. This would appear to be a promising line of work, and it will be interesting to have from Mr. Roberts at some future time a fuller account of his work and of the ideas that accompany it.

Our engineering societies are manifesting considerable interest in the Universal Exposition to take place at Paris next year, and it is likely that a large number of their members will cross the Atlantic to see the big show, and to take part in the proceedings that will be contemporaneous with it. The American Institute of Electrical Engineers has, I learn, received special invitations and tenders of hospitality from the Institution of Civil Engineers and from the Society of Arts. The latter body hopes to see the members present at its *conversazione* in June, and the Civil Engineers propose to make such arrangements as will render the visit as useful and agreeable as possible. Similar invitations have been extended to the American Society of Civil Engineers and the American Society of Mechanical Engineers, and it is understood that the three bodies, joined perhaps by one or two others of similar character, will arrange to make a combined trip, all the members and delegates going over together. The present indications are that the number of members and their families will be so great that it will be necessary to devote a steamer exclusively to their use, and negotiations with this in view are already going on with the steamship companies. This being the case, you may as well be prepared for an influx of American scientists and professional men.

Electric railways are beginning to fill a large place in the public eye, and the big cities are becoming jealous of the facilities already enjoyed by the inhabitants of smaller places that they have been inclined to look down upon as provincial and slow. Boston has just got its Sprague and Bentley-Knight road into operation, and at last the conduit for the Bentley-Knight system is being laid down in Fulton-street, between the tracks that have already been there for at least a year. Our New York aldermen also, after a spell of stupid opposition, have yielded to the inevitable, and have voted to allow the operation of the Julien storage battery cars on the Fourth Avenue-road.

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The situation daily becomes more hopeful and promising, and the claims of the electric railway people do not lose any of their vigour or effect, from the fact that Mr. C. B. Holmes, who is one of the most prominent cable railway men in the country, has just invested some of his own money and that of other people in the electric railroad at Los Angeles, California, where he promises that the finest electric service in the country shall soon be in operation. Mr. Holmes is a keen, far-sighted man, who began with horse railways, then gave Chicago its present cable system, and now tenders his support to electricity as the coming thing.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *January 5 h.*

On the 19th December the Vienna Town Council visited the central electric lighting station of the Imperial Continental Gas Association in the Schenkenstrasse, led by the Burgomaster, Dr. Uhl, and followed by most of the leading officials and engineers. They were received by the general manager of the company, Mr. H. V. Lindon, Dr Tiltscher, their Vienna representative, and Mr. T. W. W. Melhuish, Assoc.M.S.C.E., the engineer-in-chief. Visiting, first, the large hall, where formerly the dynamos stood (which is now turned into a workshop), a collection of various instruments and apparatus, specially arranged for the purpose, was shown to them. From here they descended by an iron staircase, passing the coal depot, to the dynamo room. This room, as well as the boiler house, is half-underground, and stands where formerly the court-yard of the house used to be. It is a very spacious, light, and airy place, covered with glass. The dynamos stand separate from the floor, and are so well put up that no vibration is felt in the room. There are, first, three Crompton dynamos coupled together, driven by Willans engines, each producing 250 amperes and 400 volts (100,000 watts); then follow five smaller ones, producing 72,000 watts each. Opposite the dynamos are the tables on which are placed the switches, measuring instruments, &c. Next to the dynamo room, divided only by a wall, is the boiler house, containing eight Babcock and Wilcox boilers, each with 131 square metres heating surface. Next to the boiler house are placed four pumps for feeding the boilers. The water being bad, a special water station for clearing the water has been built. This contains three large apparatuses, each clearing 4½ cubic metres per hour. Above them are placed the water reservoirs, containing 260 cubic metres of water.

The company are boring for water on their premises, but though the borehole has already reached 284 metres only very little water has been found. This is the more disappointing since the premises are only 176 metres above the sea, and the Danube is nearly 260 metres above the bottom of the borehole.

After having seen all the arrangements the Burgomaster thanked the officials of the company for their kind invitation, and expressed the satisfaction of the Town Council at having been able to see so splendid an installation. Considering the opposition the company had to encounter from the Town Council when they started their central station, this must be most gratifying to them. On Thursday, the 27th ult., the Society of Austrian Civil Engineers proposed to visit the station.

The well-known health resort, Marienbad, Bohemia, is to be lit by electricity next season. Thirty-five arc lamps of 1,000 candle-power each, and 50 glow lamps of varying candle-power are to be used for the public streets. As reserve for lighting private houses, about 1,300 glow lamps and 16 arc lamps are to be provided. The Town Council intend to undertake the whole installation at their own risk. The central station is to be built near the railway station, and Messrs. Ganz and Co., of Budapest, are said to have secured the contract. Overhead wires will be used.

This summer Passion Plays are again to be acted in Brixlegg, and preparations are already being made. One of the new improvements suggested is the lighting of the theatre by electricity, thus utilising one of the most modern inventions in helping to keep alive one of the few remnants of mediævalism. It is only to be feared that the special charm of these plays will be taken away by modernising them too much.

The Electric Light in Rome.—The *Bolletino delle Finanze Ferrovie* states that the municipal authorities of Rome have appointed a committee to report upon a proposal to extend the electric light to the whole of that city. The proposal has been made by the Societa Anglo-Romana per l'illuminazione di Roma col Gas ed Altri Sistemi.

CORRESPONDENCE.

THE DISSIPATION OF FOG.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the discussion commenced in your columns concerning the electrical dissipation of fogs, I venture to state that I have been considering for some time past a series of experiments in this direction, amongst which is the utilisation of a balloon, not only for the dissipation of fogs but also for the precipitation of rain. I hope before long to have some practical suggestions to make public. At present the results of my planned experiments are to me so speculative that I will refrain from prophecy.—Yours, &c.,

ERIC STUART BRUCE, M.A., Oxon,
Fellow of the Royal Meteorological Society.

10, Observatory-avenue, Kensington, W., 8th Jan., 1889.

ELECTRICAL DISSIPATION OF FOG.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I may as well take advantage of the opportunity afforded by your further note to say that, so far as preliminary small-scale experiments on different kinds of fog are concerned, they have all been done. Besides chemical smokes of various kinds I have dispersed steam, and turpentine smoke, and coal smoke, and sulphur, and mixtures of all of them. I have made stuff like that in a sulphuric-acid chamber by burning sulphur and supplying nitric acid vapour, and steam from a boiler. All manner of nameless abominations have been tried, and all are amenable to the electrical influence.

The whole question is now one of quantity. No doubt it can be done if enough electricity is sent up at a sufficiently high potential. The quantities concerned in natural atmospheric electricity are not hopelessly beyond imitation—the potentials are, except by reason of some automatic replenishing or intensifying action in the atmosphere. But for the clearing of fog, a potential sufficient to cause easy discharge from points or flames is sufficient, and this I believe is attainable, even combined with the requisite quantity. But it is not a small matter; a good many horse-power are necessarily involved, and unforeseen difficulties may arise as soon as large scale experiments are attempted.

It is a thing that, sooner or later, however, must be tried, and there is nothing but cost to prevent the trial being soon.

Perhaps I may trouble you to reprint the following extract from the *Journal* of the Royal Institution of Great Britain (for May, 1886). It was the conclusion of my Friday evening lecture there some three years ago.—Yours, &c.,

5th January, 1889. OLIVER J. LODGE.

[EXTRACT.]

"Leaving these sublunary and industrial applications, let us ask finally if there may not perhaps be some possible mode of artificially affecting atmospheric conditions by means of electricity. It certainly seems to me rather probable, and I should much like to have the means of discharging a large quantity of high-pressure electricity into the air, either for the purpose of acting on a fog, or in the hope of perhaps affecting the weather.

This much I regard as certain, that if a kite or a captive balloon (a kite for windy days, a balloon for calm ones) be flown into a cloud, and made to give off electricity for some time, that cloud will begin to rain.

It is just possible, though hardly probable, that by the automatic coalescence of drops into larger ones, the potential of the charge so given could become high enough to cause an artificial thunderstorm.

The amount of electricity in a thunderstorm is not very great (Faraday reckoned it as less than the amount in a thimble-full of water, and he was quite right); its potential is enormous, but there is certainly some automatic regenerative action going on in the atmosphere, which is able to raise the potential of a given charge higher and higher until a flash occurs.

It is well known, from observations made with Sir W. Thomson's atmospheric recorder, that variations in the electrical condition of the air precede a change of weather; but it is not known which is cause and which is effect in this case.

With a very large voltaic battery, such as that constructed by Dr. de la Rue, or perhaps even a bigger one, of sufficient E.M.F. to give a constant brush discharge from points, a tremendous quantity

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of electricity could be poured into the atmosphere, and its electrical condition could be certainly disturbed.

Whether this disturbance would be beneficial or not is, I know, another matter. I do not see how one is to tell without trying the experiment.

Perhaps usually the weather is best left alone; but there are times when any change feels as if it must be for the better.

Very little is known at present concerning the causes operating in the formation and dissipation of those cyclones which act so powerfully on our climatic conditions as to be now the main object of study with meteorologists, since Mr. Buchan proved to us their existence and showed us how to study them. Some of them are gigantic, but some are small and almost local whirls. A long way we are at present from even entertaining the idea of artificially controlling them; but we have learnt to control a great number of natural agents—torrents, cataracts, fire, electricity, and the main effect of a thunderstorm on a civilised town is now merely to clear its air and stir up its lightning conductors. Storms, earthquakes, and volcanoes, we have not yet learnt to control, perhaps we never shall. Perhaps also we may always remain unable to exert any effect, even on ordinary winds, clouds, and rain; but the interests involved at certain seasons of the year in the presence or absence of a succession of rain-compelling cyclones, or of frost-and-sun-transmitting anti-cyclones, are so prodigious, that even the barest glimpse of the possibility of exerting any kind of effect upon these great agents is worth attention, and it is a subject eminently suited for experiment. The experiments, however, must be on a large scale, and must be costly. Were it not so, I for one should not hesitate to make some preliminary attempts in the direction indicated."

ELECTRIC TRACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry to take up valuable space in your journal for the purpose of defending myself against the repeated attacks of Mr. T. Parker, who assumes now that I have produced a novel form of battery plate merely for the purpose of "getting around or evading the patents held by the Electrical Power Storage Company," and alleges having "seen similar plates either in the day of his (my) connection with this company or previously, these plates having been set aside on account of their difficulty and cost of construction." I had the privilege of being connected with the Electrical Power Storage Company at the time when the works were organised, and for a considerable period afterwards, but no attempts at making similar plates ever came under my notice. I had occupied myself with secondary batteries before this eminent company, or any similar company, existed in this country. My intention for many years had been to produce a plate which would stand rough usage and high rates of discharge with a minimum depreciation. Some time after I left the Electrical Power Storage Company I commenced experiments with the object of producing plates of the description given in *The Electrician* of Dec. 14th, 1888. The difficulties I experienced were very great, just as Mr. Parker imagined when penning his letter, and I resolved more than once to discontinue the work, which had worried my mind and involved so much time and expense. But I could no more give up the idea of improving secondary batteries than relinquish my favourite subject, electric traction. I continued, with the assistance of Messrs. Stephens and Smith, until we brought the battery to a commercial success, which success is warranted by our ability to make traction cells at a reasonable cost, and maintain them at the rate of one penny per car mile on ordinary tramways.

Although proud of my achievements, I would willingly recommend purchase or use storage batteries of anybody's make if they proved to be cheaper and more durable than mine. I am just as anxious as Mr. Parker that the "public shall be thoroughly cognizant of all its merits," and if I have been the means of raising the status of the storage-battery industry, and have at the same time proved its utility for electric traction, I am satisfied, for the reward is steadily flowing in.

I have no desire to discuss the technical details any further, they have to stand on their own merits; but in connection with the very delicate points raised by Mr. Parker I may add that some time ago, when our success was fully assured, friends of mine approached Messrs. Elwell-Parker and the Electrical Power Storage Company with a view of inducing them to utilise my invention, but neither of those firms cared to take it up, nor did they seem to appreciate its advantages.—Yours, &c.,

London, January 7th, 1889. A. RECKENZAUN.

THE RECKENZAUN STORAGE CELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think it only justice to Mr. Reckenzaun to state that no plate resembling those described in your issue of Dec. 14th last was made or suggested during the time I was engaged as chief electrician to the Electrical Power Storage Company. All experimental work passed through my hands from the day the works and laboratory were started until I left, early in 1884. I think Mr. Parker must be under a wrong impression. I can also state the fact that Mr. Reckenzaun worked on electric traction problems long before the Electrical Power Storage Company existed, having seen various devices at his house at that early period.—Yours, &c.,

CH. CAPITO.

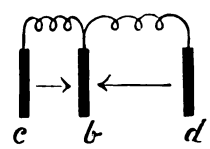
9, Belgrave-terrace, Lee, S.E., Jan. 7th, 1889.

PRIMARY BATTERIES FOR LARGE CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Ross in his letter of the 24th ult. gives certain reasons why primary batteries may be installed to greater advantage on a large scale. Undoubtedly this is so, but by far the most important of the points enumerated is that referring to the utilisation of products. If Mr. Ross can show that the products referred to, made on a large scale, will meet with a correspondingly large and remunerative demand, and that the cost of lighting by this method can be reduced to that by the engine and dynamo, there will then be a truly promising future for the primary battery.

As the success or failure of the primary battery as an extensive lighting agent lies almost entirely in the solution of this problem, I venture to offer a suggestion whereby some of the products may be utilised again for further action at the expense of a comparatively cheap acid. I refer to the principle of regeneration, which I think has hardly received the attention that its many advantages would have justified. It is not only possible to construct a cell that will revivify its own depolarising solution when at rest, but will do so when in action. If the negative plate of a primary cell consist of two such substances as copper and carbon, a secondary and local action may be established whereby, in the case where hydrochloric acid is employed, a chloride of copper will be formed. This chloride being soluble in hydrochloric acid performs the function of depolarisation. Now, it may seem somewhat illogical to assume that two opposing actions can take place at the same time; but the following diagram will, I think, show that although the



E.M.F. will be lowered by reason of the tendency of the deposited copper on the zinc side to reform into a chloride, still it is possible that such action can go on outside the influence of the main circuit. In the diagram given *a b* and *c* are respectively zinc, carbon, and copper plates, and the arrows show the direction of the currents under the liquid. As soon as the cell is set up chloride of copper is formed at the copper plate, the circuit between the copper and carbon being always closed, and this action continues whether the main circuit be closed or open. If the main circuit between the zinc and carbon plate be closed, hydrogen forms on the carbon, and is immediately taken up by the chlorine of the copper chloride, copper being deposited. When the main circuit is open the chlorine of the acid attacks the copper deposited on the carbon, much in the same manner as an unhomogeneous zinc will be rapidly deteriorated by small local closed circuits, and hence the cycle of actions is kept up at the expense of the hydrochloric acid.

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By such a system it will be seen that a comparatively cheap acid is all that is necessary to replenish the negative vessel, that there is no useless remnant of a partially expended and expensive depolarising fluid, and that the internal resistance remains a constant quantity. I have carried out various experiments with this class of cell, and have obtained remarkable constancy; but as it stands I fear the internal resistance is somewhat too high for lighting purposes, although it is consideraby under that of a Leclanché of same capacity. I hope soon to be able to give some further particulars; but in the meanwhile I have brought the subject forward with a hope that others will be induced to enter into a very promising field of investigation.—Yours, &c., N. G. Thompson.

7, Westminster-chambers, Jan. 8.

[Our correspondent's ingenious idea does not, however, touch what is, after all, the real *crux* of the problem, namely, the regeneration of the zinc.—Ed. *E.*]

THE APPLICATION OF THE PROJECTOR IN THE TRAINING OF HEAVY GUNS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I notice your extract from a contemporary, referring to Messrs. Goolden and Co.'s proposal to apply electric projectors to the sights of guns, and your reference to my experiments with range-finding appliances. You will, doubtless, recall our conversation on the subject some 18 months ago, soon after my return from Chili. Since then I have met many officers who have used the projector for range-finding, with different degrees of success.

Though there is no novelty in Messrs. Goolden and Co.'s proposal, it will be interesting to see the details of their plan for mounting search lights on guns. I have tried this, and know something of the practical difficulties involved. The measure of success which attended my work in this direction was mainly obtained with an arrangement in which powerful projectors were mounted on circular platforms above the machine guns of a cruiser. Both projectors and guns were mounted on the masthead, and had thus a very wide range. The angle was read off to the gunner immediately below, and excellent practice could be made within ranges of 1,000 yards on the darkest nights. But I question the expediency of actually connecting projectors with the sights of guns. In my opinion the further the projector is removed from the gunner the better. One of the first of naval qualifications is powerful eyesight, and nothing is more trying, perhaps nothing more ruinous to the eyesight, than the manipulation of search lights. The glare of light from a ship's deck which would result from the use of so many lights would seriously interfere with the navigation of the vessel. The best method, perhaps, is that now most in use, viz., the application of the projector, not to gun sights, but to the range-finder. The development of naval electric appliances may well be left in the hands of the numerous energetic young naval electricians among the officers of our squadrons, who understand the problems they have to tackle, and appreciate the value of electricity as an ally to accuracy and rapidity.—Yours, &c.. Alfred E. Mavor.

Forth Bridge, South Queensferry, N.B.
January 8, 1889.

ELECTRICITY METERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The use of electricity, either as a lighting or as a motive agency, necessarily implies the use of some kind of instrument to measure the power used by the consumer. So far as my experience goes I do not know any meter that unites the qualities of a simple and accurate measurer of the energy actually consumed, but as many electricians have doubtless solved the problem to their own satisfaction, I think it would be of general interest to your readers if they would publish in your columns the results of their experiments,and their opinion as to the best meter in the market.—I am, &c.,

John F. Forrest.

Glasgow, January 4, 1889.

BLONDLOT AND CURIE'S ELECTROMETER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I was much interested by your description of MM. Blondlot and Curie's electrostatic wattmeter, as about two years ago I was working upon the same lines and devised an instrument which seems to have been not unlike theirs, and which consisted of a quadrant electrometer with a needle whose opposite halves were insulated from each other.

The method of using the instrument can be best explained with the aid of a diagram.

If A and B, 1 and 3, 2 and 4, were respectively connected together, an ordinary quadrant electrometer was the result. I proposed to use the instrument as a wattmeter by connecting together 1 and 2, 3 and 4 respectively, and joining A and B to the terminals of the conductor by which the watts to be measured were absorbed, and 1 and 4 to the terminals of a known non-inductive resistance in series with it, or else joining A and B to the non-inductive resistance, and 1 and 4 to the other conductor.

But whether the quadrants were designed according to the "pill-box" or the "cylinder" pattern a difficulty arose which seemed inseparable from the kind of instrument, and which ultimately compelled me to abandon my plan, and I am curious to know whether MM. Blondlot and Curie consider that they have surmounted it.

The difficulty is as follows:—If V_1 V_A denote the potentials of 1 and A at any moment, and a similar notation be employed for the other bodies, it is very easy to prove that, when the instrument is in adjustment, and 1 and 2, 3 and 4 connected, the moment of the forces on the needle round its axis is proportional to $(V_1 - V_4)$ $(V_A - V_B)$; but the action on the needle is, nevertheless, not in general a pure couple, as is the case in the ordinary quadrant electrometer, at least in theory. For example, if V_A, V_B, V_4, are nearly equal, but V_1 widely different from them, the needle, as a whole, will experience a force urging it towards 1 and 2, and away from 3 and 4, besides a couple tending to turn it round its axis, and the effect of this force will be to displace the axis of rotation relatively to the quadrants, and thus to throw the instrument out of adjustment; and so the above formula will no longer apply.

If V_1, V_4, and V_A are nearly equal, but V_B widely different, a similar displacement of the axis of rotation will result; in fact, owing to the unsymmetrical character of the arrangement, it is only in the case in which $V_A + V_B = V_1 + V_4$ that the action on the needle is a pure couple, and the formula given may be expected to hold.

I have mentioned specially the cases in which three of the potentials were at any moment nearly equal, while the fourth was widely different, as these are the conditions during the measurement of the power absorbed by a transformer while its secondary circuit is open. The uncertainty of such a measurement when made by a wattmeter possessing self-induction was insisted upon in *The Electrician* some time ago, though its importance from a commercial point of view seemed to me to have been somewhat exaggerated, and it is a curious coincidence that exactly the same case should for such a widely different reason prove the most unfavourable one to the electrostatic wattmeter.

These considerations are the more important because it appears to be very probable that the "coefficient of aberration" of quadrant electrometers mentioned by Prof. Ayrton is also due to slight departures from symmetry, which make the

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position of the axis of rotation of the needle when the quadrants are all connected together dependent upon its potential relative to them, though of course the "aberrations" of the electrostatic wattmeter will be enormously greater.—Yours, &c.,

L. R. WILBERFORCE.

Spring-grove, Isleworth, January 9, 1889.

[We may remark that in the Blondlot and Curie instrument the objection raised by our correspondent is, *to some extent*, obviated by the suspension of the needle from the top and bottom of the case, as in a marine galvanometer. But it is, perhaps, questionable whether the remedy is perfect.—ED. *E.*]

THE ELECTRIC LIGHT AT GALWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may interest you to know that out here in the far west of Ireland electric lighting is making its way. For some time we have illuminated a part of the old town with arc lights, and we are busy now with incandescent lighting for private work, and we have a number of engines for motive power. We are a private local company, represented professionally by Mr. James Perry, M.E., the county surveyor of Galway, and Mr. Arthur W. Slater, A.I.E.E.

We have acquired some extensive mills, with ample water-power, and have made arrangements for more power should we at any time require it.

Our proposals for lighting towns are being considered, and it looks a good sign that the commissioners have informed the gas company that their arrangement with them may end with the financial year.

As soon as our mains are completed we shall be in a position to supply our numerous customers. Our lighting has had the effect of reducing the price of gas from 6s. 6d. to 4s. 9d. per 1,000 cubic feet.

Trusting this information may interest you.—Yours, &c.,

THE GALWAY ELECTRIC COMPANY.

THE INVASION OF BATH BY THE HOUSE-TO-HOUSE COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As many of your readers are aware, I have just succeeded (after three years of unremitting efforts) in inducing my fellow-citizens to introduce the electric light into Bath for public and private use, and have obtained from the Corporation a seven years' contract (on behalf of a local supply company) for the public lighting of fifty of the principal streets, squares, and crescents of this city with arc lamps. Plant will shortly be put down for 200 arc lamps and 1,000 incandescents.

I am not, as many suppose, a professional electrical engineer, but only an enthusiastic admirer of "the light of the future." During the past four years I have unstintingly spent my own time and capital in introducing electricity into several towns in the West of England, in the prosperity of which I am personally interested.

To my surprise, just as we are on the eve of forming our local company, the House-to-House make an application to the Bath City Council asking them to sanction their applying to the Board of Trade for a license for lighting the same area for the same term of years. What is the meaning of this application? Are the House-to-House Company imitating the behaviour of the Maxim-Weston Company under the chairmanship of Mr. Hugh Watt, M.P.? The unjustifiable interference of the Maxim-Weston some twelve months ago, just as the Commissioners of Sewers were contemplating entering into a contract with the Brush Corporation for the lighting of the City, was not only a loss to that particular company, but still more so to the whole of the electric lighting industry. The only effect of this application is to frighten a certain number of timid investors, who will be afraid to apply for shares in the Bath Electric Lighting Company if labouring under the mistaken impression that it is going to be subjected to the competition of a powerful London company with an unlimited amount of capital behind it.

Even if the House-to-House possessed the necessary capital to erect a large central station they would obtain no custom, as they could not compete with the local company except at a ruinous loss. The sooner companies which pursue this "dog-in-the-manger" policy cease to exist the better it will be for the electric lighting industry, the growth of which they retard by their short-sighted policy.

Trusting that this candid expression of my views may produce beneficial results.—Yours, &c.,

H. G. MASSINGHAM.

ALLEGED PIRACY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have noted in your last issue a letter signed S. Sudworth which evidently refers to our firm and catalogue, and in answer thereto we can only state that the assertions made therein have no foundation in fact. At the same time we wish to mention that Mr. E. L. Berry, whose name was referred to by Mr. Sudworth, has written to us saying that the letter was published without his knowledge or authority.—Yours, &c., G. BINSWANGER AND CO.

5, Great St. Thomas Apostle, 7th January, 1889.

EXECUTION BY ELECTRICITY.

BY SYDNEY F. WALKER.

The State of New York has decreed that from henceforth, if men must die by the hand of the law, electricity shall be the agent employed and not the rope.

The object of the law is, apparently, to secure that death shall be more painless, and that there shall be no chance of the painful scenes that have been so common at the gallows within recent years.

While fully recognising the humane spirit which has prompted the enactment of this law, is it really humane after all? Is it clear that death by electricity, in the present state of our knowledge of the subject, will be more painless and more sure? Do we know how to kill a man surely and painlessly? The writer ventures to affirm that no one can furnish rules for killing a cat surely by electricity, and without pain, much less a human being in the full vigour of man or womanhood.

It is assumed by the humanitarians who have procured the passage of the law, and apparently by the criminals whom the *Sun* reporter interviewed upon the subject, that all that would be necessary would be for the condemned man or woman to seat himself or herself in an armchair, and sleep off. And the ground for this belief is the number of deaths that have unfortunately occurred through incautiously handling wires and apparatus carrying high-tension currents. As a matter of fact, we are at present in absolute ignorance of how these people have been killed. We have nothing to guide us as to the electromotive force or current to be employed, nor whether these should vary with the age, size, weight, or sex of the object. The accounts furnished are most contradictory. In the early days of electric lighting, several deaths occurred from incautiously handling the wires and lamps carrying alternating currents. In one case, that of the stoker on board the Czar's yacht "Livadia," the voltage could not have been high, if the reports were correct. More recently, responsible American electrical engineers have stated that the alternating current is not so likely to be fatal as the continuous current, and instances have been mentioned of 1,000 volts being taken through the hands without injury. Again, there was the case at the Health Exhibition, where a man was killed by 1,200 volts from a continuous-current machine; and more recently a waitress at the Newcastle Exhibition received a very severe shock from incautiously touching an arc lamp on a circuit, the full tension of which was only 200 volts. The writer has himself repeatedly received the shock of 200 and 300 volts, plus the extra current generated on breaking the circuit of a series machine. M. d'Arsonval has stated that he has killed guinea pigs with 60 volts.

But if all the reports and all the experience available be put together, the knowledge imparted as to how the current acts inside the body, or what it does, is not equal to that possessed by a first year's student of electrical engineering, respecting the action of the electric current upon every apparatus that he handles.

Even the use of electricity for healing purposes is mere guess work. No member of the medical profession has followed the current inside the human body, in the same way that the electrical engineer follows it into electrical apparatus. Even the most

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advanced of electro-medical scientists has only discovered that there are enormous differences in the electrical resistance offered by the human body, as great as from 500 ohms to 6,000 ohms; and even he cannot tell us how the current divides when it is inside the body, nor what is its effect upon each membrane, bloodvessel, &c. And if this is so, will not the earlier executions, at any rate, resolve themselves into experiments? and further, will not a great number of experiments be necessary before a simple rule can be formulated, such as should be available for the old method. Is not the idea of a healthy man, clad in woollens or cottons, seating himself in a wooden arm-chair, however much patented, and sleeping off, sheer nonsense? How is the current to be applied? Is it to pass through the wood and the clothes of the criminal, and if so, what tension will be required, and how will the operator be insulated himself?

Prof. E. J. Houston has pointed out in an able Paper recently read before the American Philosophical Society, that for death to ensue, some vital part of the body must lie in the path of the current, such as the brain, the lungs or the heart; and that in those cases where death has been caused by electricity, the current has passed either from the head or neck to the feet, from either arm to one or both feet, or, lastly, from hand to hand. Would not some arrangement have to be made involving similar conditions where the object was to kill? and would it not necessitate pinioning, the procession, and all that condemned criminals so justly dread? Further, are there not far more chances of an electrical apparatus going wrong, especially in the only hands that could be got to work it, than the rope? Is not the problem of killing a man by electricity, under the necessary conditions, a hundred times more difficult than the simple mechanical problem involved in hanging?

If, then, blunders occur on the old plan through sheer carelessness where it is difficult to fail, would they not be almost certain under conditions requiring great skill and care? Would it not be wiser, therefore, to adopt the old-fashioned plan of learning how to do a thing before experimenting on human beings?

Will any humanitarian imagine to himself a criminal tied in his chair, tied to his conductors, the funeral service going on, and the operator vainly endeavouring to get the apparatus to work, perhaps owing to a change in the weather, each moment growing more and more nervous; and ask himself if that would not be a step back to the old days of torture?

Let humanitarians and members of the medical profession first study the human body as an electrical apparatus, and a very delicate one; let them follow the current in each of its numerous paths inside the body, and ascertain what its effect is on each organ, each membrane, each nerve, &c., and then, if they think well, let them arrange to execute by electricity, as they should then be able to accomplish it surely and painlessly; and more than that, the knowledge so acquired should be of more value to them and to the human race than all the books on medicine that were ever written.

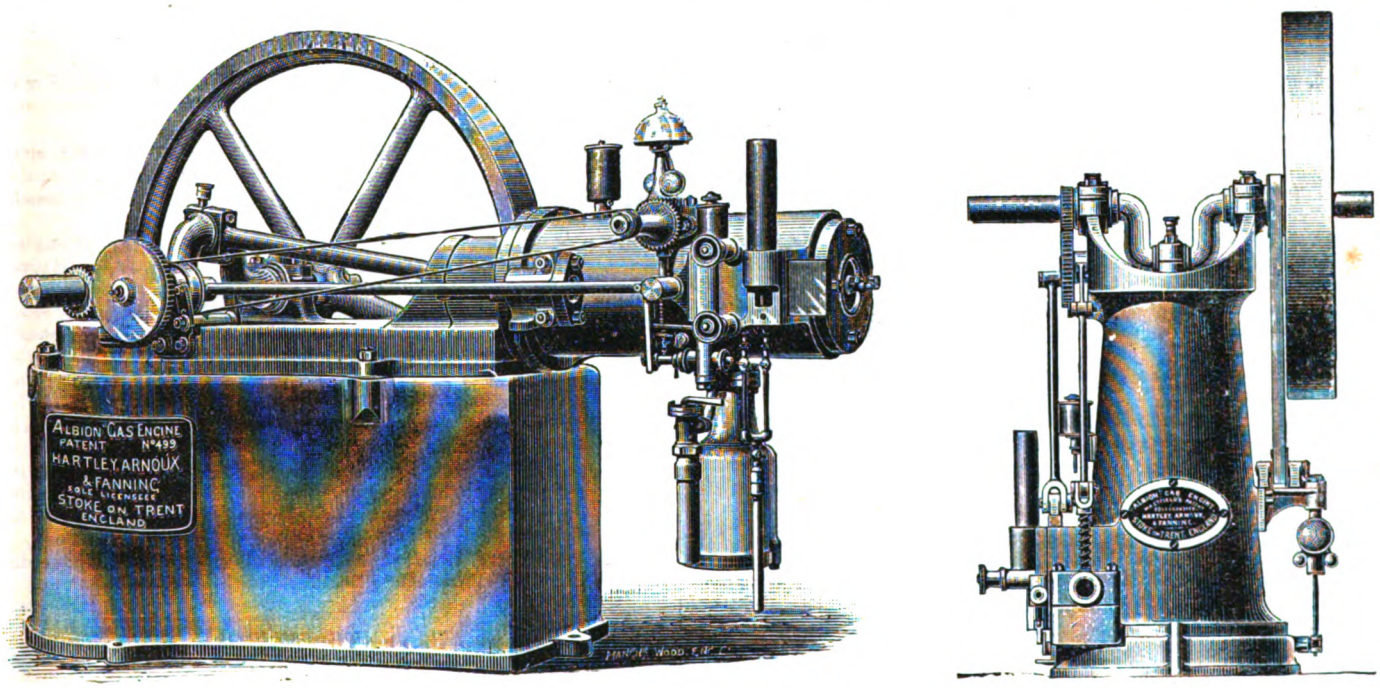
THE "ALBION" GAS ENGINE.

This gas engine, which has recently been introduced by the Albion Engine Company, is of a new type, and will, it is said, run with a consumption as low as 13½ cubic feet of gas per nominal horse-power per hour, including the firing jets. We know of no other gas engine which is capable of equalling this performance, and if verified it would mark a very decided improvement. The engine is made either horizontal or vertical, as shown in the adjoining figures.

In the construction of the engine the great aim has been simplicity, with the result that it contains a very small number of parts. The slide works on the side of the engine, the charge is fired from the centre, and the combustion of the gas being practically perfect, we are told that no carbon is deposited in the passage of the slide over the ports, and the slides will, as a consequence, run for months without removal. The engine can be run at a slow speed, or accelerated to 350 revolutions per minute.

With some gas engines in the market the cost of oil, or other lubricant, is very high. This, it is claimed, is not the case with the Albion gas engine—firstly, because of the much fewer parts, and, secondly, owing to the easy and steady working of the slides. The makers guarantee to "repair or replace any parts of these engines which may be broken, or suffer from undue wear within six months after delivery."

By a special arrangement with the manufacturers of a well-known and approved dynamo, the Albion engine is now supplied for electric light installation in a very neat form. In the case of the vertical motor a special bedplate carries the dynamo, which is driven direct off the flywheel of the engine. In order to readily start it an arrangement is used allowing the motor to be started without actuating the dynamo, thus rendering starting easy, as well as enabling the motor to be utilised for driving purposes, independent of the dynamo. But at will the latter can readily be connected with the engine. The same arrangement also allows of a simple means of taking up the slack of the driving belt by means of the same hand wheel and screw which is used to couple the gas engine and dynamo. In the case of the larger horizontal engines the dynamo is bolted to the underframe of the engine, so that where space is valuable no additional room other than that on which the engine stands is needed. This forms a very neat and efficient combination, and is giving universal satisfaction to users. Full particulars of either the above engines will be forwarded by Messrs. Hartley, Arnoux and Fanning, Stoke-on-Trent.



The "Albion" Gas Engine—Horizontal and Vertical.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

17,063. H. A. B. Huguet (de Vars). London. A new or improved electric-spray-producing apparatus. November 23, 1888.

17,123. C. A. Mayrhofer. London. Improvements in apparatus for electrically regulating or synchronising clocks. November 24, 1888.

17,127. D. Y. Cliff. London. Improvements relating to the conveying of electrically-charged wires. November 24th, 1888.

17,155. E. W. Lancaster. Birmingham. Improvements in electrical spring switches. November 26, 1888.

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17,163. F. L. Rawson and W. White. London. Improvements in electrical switches and other electrical instruments. November 27, 1888.

17,178. W. M. Mordey. London. Improvements in electric motors. November 26, 1888.

17,222. L. Paget. London. Improvements in electric lamps or lighting apparatus. November 27, 1888.

17,223. L. Paget. London. Improvements relating to electric secondary batteries or accumulators, and to the manufacture of electrodes therefor. November 27, 1888.

17,224. L. Paget. London. Improvements in and relating to electrical apparatus for propelling tramway and other vehicles. November 27, 1888.

17,225. L. Paget. London. Improvements relating to the generation of electricity and the simultaneous production of zinc chloride and other bye-products. November 27, 1888.

17,238. G. C. Dymond. Liverpool. Improvements in or relating to dry piles for electrical purposes (L. Moorthamers, Belgium). November 27, 1888.

17,249. F. Teague. London. An improvement in electric meters. November 27, 1888.

17,289. H. W. Houlden. Doncaster. Improvements in gearing for electric tramcars, &c. November 28, 1888.

17,325. A. W. Armstrong. London. An improved combined electric bell, battery and push for street door and other purposes. November 28, 1888.

17,326. A. W. Armstrong. London. The adaptation of electricity or clockwork in conjunction with either lenses, reflectors or an aphengescope, or combined to transmit different advertisements automatically without manual power. November 28, 1888.

17,340. P. M. Justice. London. Improvements in electro-depositing cells (E. L. Smith, United States). November, 28, 1888.

17,353. G. Durham. Stockport. Combination automatic commutating and electric fire and police alarm and public alarm. November 29, 1888.

17,394. G. Binswanger and H. Hirst. London. Improvements in electric lampholders. November 29, 1888.

17,420. A. Wylie. London. Improvements in the method of, and in machinery for the manufacture of metallic pipes and rods, and for covering the same, and telegraph and telephone cables and wires, with lead or metallic compounds for electric purposes. November 29, 1888.

17,443. J. Gibson and C. B. Gibson. Edinburgh. An electric apparatus for choosing partners for purposes of amusement and otherwise. November 30, 1888.

17,479. F. B. Nicholson and E. J. Jennings. London. Improvements in switches and appurtenances used in an electric current. November 30, 1888.

17,489. L. Fougue. London. Improvements in electric batteries. November 30, 1888.

17,535. L. M. Davis. London. An improvement in or addition to electrically operated combination apparatus for domestic use. December 1, 1888.

17,537. M. Bailey and J. Warner. London. Improvements in cells for secondary batteries. December 1, 1888.

17,568. L. Paris and Scott (Limited), and R. Lawrence. London. Improved means in connection with multiple electric circuits for measuring current passing in either of them as desired. December 1, 1888.

17,590. H. P. Holt. Manchester. Improvements in apparatus and devices for carrying and separating the plates of secondary batteries. December 3, 1888.

17,601. H. W. Handcock. London. Improvements in the construction and arrangement of electrical bells. December 3, 1888.

17,619. B. M. Drake and J. M. Gorham. London. Electrical measuring instrument. December 3, 1888.

17,630. S. Mathis and E. Boveroulle. London. Improved means and apparatus for effecting the successive bringing into action of two or more carbon pairs in electric arc lamps. December 3, 1888.

17,642. J. Moseley. Manchester. An improved separator for the plates of primary and secondary galvanic batteries. December 4, 1888.

17,645. S. C. C. Currie. Birmingham. Improvements in electro-motors. December 4, 1888.

17,688. S. H. Short. London. Improvements in and connected with electric railways. December 4, 1888.

17,694. H. J. Harris and J. Garford. London. Improvements in voltaic batteries. December 4, 1888.

17,718. T. Parker and E. S. G. Rees. Manchester. Improvements in electric cut-outs or circuit breakers. December 5, 1888.

17,746. W. H. Sturge. Birmingham. Improvements in the manufacture of ceiling roses, switches, cut-outs, or other similar electrical fittings. December 5, 1888.

17,765. W. Markby. London. Improvements in electrical railway signals. December 5, 1888.

17,783. G. A. Sweetser. London. Improvements in the manufacture of wire or tape from electro-deposited metal for electrical or other purposes. December 5, 1888.

17,792. M. R. Ward. London. Electrical street car, and appliances for working the same. December 5, 1888.

17,795. J. Brockie. London. An improvement in electrical arc lamps. December 6, 1888.

17,798. A. S. Dunn. Glasgow. Improved insulating apparatus for terminating or shackling and looping telegraph, telephone, and other electrical wires. December 6, 1888.

17,850. W. R. D. Frost. London. Improvements in electric meters or apparatus for measuring electricity. December 6, 1888.

COMPLETE SPECIFICATIONS ACCEPTED

Note.—*All persons interested in opposing the grant of a patent on any one of the undermentioned applications may, at any time within two months from the date in italics, give notice at the Patent Office in the prescribed form of such opposition.*

December 1, 1888.

17,726. J. G. Statter. London. Improvements in or connected with electromotors. December 24, 1887.

1,213. J. T. Leighton. London. Improvements in the application of electricity to spectacle frames. January 26, 1888.

1,383. F. Borel and E. Paccaud. London. Electric apparatus for use either as an electric motor or as an electric current meter. January 30, 1888.

11,065. W. P. Thompson. Liverpool. Improvements in or relating to apparatus for supplying variable amounts of electricity to and thus regulating the brilliancy of electric lamps (G. Westinghouse, jun., United States). July 31, 1888.

11,681. C. E. Liebert and S. A. Rosenthal. London. Improvements relating to electric batteries and to exciting liquids or compounds therefor. August 13, 1888.

15,388. A. Shippey. London. Improvements in apparatus for regulating dynamo-electric machines (A. G. Waterhouse, United States). October 25, 1888.

15,612. J. C. Love. London. Improvements in insulators for electrical conductors. October 30, 1888.

December 8, 1888.

17,138. R. H. Courtenay. London. Improved apparatus for generating and converting electric currents. December 13, 1887.

17,415. J. G. Lorrain. London. Improvements in electrical measuring and recording apparatus. December 17, 1887.

17,966. O. Y. Rhodes. Halifax. Improvements in electric batteries and in the application thereof to the lighting of miners' safety lamps. December 31, 1887.

1,875. G. Hookham (Birmingham) and R. H. Housman (Bromsgrove). Improvements in dynamo electric machines and in electromotors. February 8, 1888.

1,891. M. Bailey and J. Warner. London. A flexible battery cell and method of arranging the elements therefor. February 8, 1888.

3,312. E. Tyer. London. An improvement in voltaic batteries. March 3, 1888.

14,984. R. R. Hutchinson. London. Improved method of and apparatus for rotating hydro-extractors by means of a current of electricity, and automatically checking or arresting the motion thereof when desired. October 18, 1888.

16,146. F. Moreton. London. Improvements relating to electro-medical batteries. November 7, 1888.

PATENTS SEALED.

December 7, 1888.

14,664. J. H. Bell and W. Rockliffe. Sunderland. Improved plates for shipbuilding and other purposes. October 28, 1887.

14,996. E. Hopkinson. Manchester. Improvements in gear for transmitting motion from electric motors to driving axles of vehicles. November 3, 1887.

15,877. J. B. Willis. Portsmouth. Improvements in telegraphic apparatus suitable for indicating the position of a ship's rudder. November 18, 1887.

16,185. W. J. S. Barber-Starkey. Bridgnorth. Improvements in electric meters. November 24, 1887.

16,772. J. A. Macdonald. Birkenhead. Improvements in electric bells. December 6, 1887.

SPECIFICATIONS PUBLISHED.

16,807, 1887. Urquhart, D. Incandescent electric lamps. (Price 8d.)

17,582, 1887. Lauckert, E. F. H. H. Indicating the time during which electricity is used for lighting, &c. (Price 8d.)

17,641, 1887. Wright, J. E., and Moore, J. Printing telegraphs. (Price 11d.)

17,807, 1887. Rawson, F. L. (Wirt). Rheostats, &c. (Price 8d.)

208, 1888. Ross, O. C. D. Utilising waste products from electrical batteries. (Price 6d.)

295, 1888. Parker, T., and Rees, E. Electric meter. (Price 8d.)

302, 1888. Parker, T. Electric meter. (Price 8d.)

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705, 1888. PERCY, L. E. Mouthpiece for telephone transmitter. (Price 8d.)
1,016, 1888. TAYLOR, A. M., Electrical transforming apparatus. (Price 4d.)
1,105, 1888. WEBSTER, W. Treating sewage by electrolysis, &c. (Price 8d.)
2,259, 1888. MESTERN, H. Thermo-electric and furnace batteries. (Price 8d.)
10,415, 1888. GASSNER, C. Electrical dry elements. (Price 4d.)
12,066, 1888. BOULT, A. J. (McLaughlin). Electrical type-writers, &c. (Price 11d.)
12,754, 1888. LAKE, H. H. (Humans). Electric bells, &c. (Price 1s. 3d.)
13,035, 1888. DORMAN, C. M., and SMITH, R. A. Socket electric lamp-holders. (Price 8d.)
13,122, 1888. PATTERSON, C. J., and COOPER, C. F. Dynamo electric machines. (Price 6d.)
14,522, 1888. HUMPHREYS, D. Galvanic batteries. (Price 8d.)
15,878A, 1887. POPP, V. Measuring the time during which a current of electricity, &c., is flowing. (Price 6d.)
17,502, 1887. HOOKHAM, G. Electricity meters. (Price 8d.)
296, 1888. PARKER, T. Switches for electric circuits. (Price 8d.)
472, 1888. WEBSTER, W. Treating sewage, &c., by electrolysis. (Price 8d.)
584, 1888. MADGEN, W. L. Supplying electric railways, &c., with electricity. (Price 8d.)
1,557, 1888. JACOB, F. Duplex telegraphy. (Price 8d.)

Second Editions.

1,769, 1882. JOHNSON, J. H. (Faure). Secondary batteries. (Price 8d.)
1,875, 1882. FITZGERALD, D. G. and others. Secondary batteries. (Price 8d.)
3,409, 1882. TAYLOR, W., and KING, F. Secondary batteries. (Price 4d.)
3,812, 1882. BEEMAN, J. S., and others. Secondary batteries. (Price 8d.)
5,601, 1882. TRIBE, A. Secondary batteries. (Price 6d.)
1,122, 1883. FITZGERALD, D. G. Secondary batteries. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Metropolitan Electric Supply Company (Limited).

An extraordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Tuesday, for the purpose of considering and, if thought fit, passing resolutions altering the Articles of Association of the Company as follows:—

Article 26. By striking out the words "A director may act before acquiring his qualification."

Article 45. By adding at the end of this Article the words "Provided that the power of borrowing and raising money and of making and issuing mortgages or debentures, or debenture stock, obligations, or other securities, shall not at any time, without the sanction of a general meeting, be exercised to such an extent that the total amount of principal money borrowed, raised, or secured shall exceed the nominal amount of the share capital for the time being, but this restriction shall not oblige any person taking any mortgage or debenture, or debenture stock, obligation, or other security of the Company, to inquire whether there has been any such excess, or affect the validity of any such security in the hands of a *bonâ fide* holder, nor interfere with the power of the directors to make and enforce calls."

Article 102. By striking out the words, "A Director shall not be appointed Auditor," and inserting in lieu thereof the words "No Director or other officer of the Company shall be appointed Auditor."

Article 119. By inserting after the word "shares" the words "not fully paid."

Article 121. By inserting after the word "writing" the words "which may be in the usual common form."

Article 123. By inserting after the word "Share" the words "not fully paid up."

Article 130. By striking out all the words except the words "Every shareholder shall be entitled to one certificate for his shares gratis, but in every other case one shilling shall where the Board think fit be paid to the Company for every certificate."

Article 155. By inserting after the word "Shares" in line 2 the words "not fully paid up."

The chair was taken by Alderman Sir R. N. Fowler, Bart., M.P., in the unavoidable absence of the Chairman of the Company, Sir John Pender, K.C.M.G.

The SECRETARY (Mr. E. Cunliffe Owen) having read the advertisement convening the meeting, as above,

The CHAIRMAN said: Gentlemen, these are alterations required by the committee of the Stock Exchange for the purpose of our getting a settlement. I will ask the Solicitor to explain the purport of the alterations.

Mr. CHARLES BURT stated, with regard to the alteration in Clause 26, that as a matter of law it had been decided by the Courts that a Director might act before acquiring his qualification, that he might have reasonable time to acquire his qualificaion; but the point had no application whatever so far as their Company was concerned, the Directors having long since acquired their qualification. The change in Article 45 was a limitation of the borrowing powers of the Company in the manner explained in the notice. This was a new requirement of the Committee of the Stock Exchange, and probably the shareholders would regard the requirement as a reasonable one. With reference to the alteration in Clause 102, which was also a modern requirement of the committee, there had been no intention, of course, so far as their Company was concerned, of appointing any Director or officer of the Company as auditor. Then the Committee, as regarded Article 119—which he read—desired that the lien on the Company's shares should be restricted to those shares which were not fully paid up, the object, he supposed, being to allow the shareholder to lodge his certificate with his banker or anyone else in such a way that he might raise money. As to the alteration in Article 121, it was well, perhaps, to express it, but there had been no idea of making it other than it would stand by the proposed change. In regard to Clause 123, the Committee desired them to insert after the word "share" the words "not fully paid up," so that when shares were fully paid up a transfer of them might be made to any person the transferror pleased. With respect to shares not fully paid up, it was necessary that the Board should have a discretion as to adopting those who might be proposed as transferees; otherwise it might happen, if the Company, or any company, were in difficulties, and a sum were unpaid on certain shares, the holder might transfer them to a man of straw in order to escape his liability. The object of the proposed alteration was to avoid that. The change in Article 130 was, to his mind, not of the slightest importance. The alteration in Clause 155 again applied to the question of the lien on shares, and again they were asked to insert the words "not fully paid-up." Those were the only alterations, and, if the shareholders had no objection, it would be convenient to take them all as one resolution.

On the motion of the CHAIRMAN, seconded by Sir JAMES ANDERSON, a resolution was unanimously passed agreeing to the various alterations in question.

The CHAIRMAN stated that what had been done would require to be confirmed at another meeting, but it would be merely formal.

Mr. BALFOUR then proposed, and Mr. KENNETH ANDERSON seconded, a vote of thanks to the Chairman.

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel last Monday, when the subjoined resolutions, which were passed at the extraordinary general meeting of the Company held on the 21st ult., were submitted for confirmation as special resolutions:—

"1. *That the liquidators of the Company be and they are hereby authorised to consent to the registration of a new company to be named the Maxim-Weston Electric Company (Limited), with a Memorandum and Articles of Association which have already been prepared with the privity and approval of the Directors of this Company.*

"2. *That the draft agreement submitted to this meeting, and expressed to be made between this Company and its liquidators of the one part, and the Maxim-Weston Electric Company (Limited) of the other part, be and the same is hereby approved, and that the said liquidators be and they are hereby authorised, pursuant to Section 161 of the Companies Act, 1862, to enter into an agreement with such new company (when incorporated) in the terms of the said draft, and to carry the same into effect with such, if any, modifications as they think expedient.*"

The chair was occupied by Mr. John Marks.

The SECRETARY (Mr. Samuel J. Boyce) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, in moving the confirmation of the resolutions just read by the Secretary, I would draw your attention to one clause in the agreement, every word in which was read at the last meeting to the shareholders, and of the contents of which I presume they have notice. One clause, however, provides that the new Company have the power to terminate this agreement if shareholders holding 30,000 shares dissent from the reconstruction scheme. Well, we know that great efforts are being made in a certain quarter to induce shareholders to dissent from the scheme, those efforts being made merely from interested motives. Mr. Abrahams told us at the last meeting that he represented shareholders holding 30,000 shares, and that he would certainly dissent from the scheme. Well, if shareholders holding 30,000 shares only dissent from the scheme, I do not think that that would be a bar to the new company carrying out this agreement with the liquidators; but if a very large number of shareholders dissent I think that the new company would then be justified in not carrying out the reconstruction scheme, because to satisfy those shareholders the money of the gentlemen taking up the new shares would have to be applied, and that would be unfair to the latter. But I merely make these remarks to point out to you how contrary it is to your own interests to dissent from the scheme. It is all very well for Mr. Abrahams to tell us that the arbitrators will give 2s. a share to each dissentient shareholder, and that is held out merely for the purpose of inducing you to dissent; but we have a very different opinion as to what the arbitrator would give. Suppose, however, a very large number of shareholders dissent and the Company do not go on with the scheme, what will then be the position of the dissentient shareholders, and also of those who do not dissent? It will be this—that the new company would drop the scheme, and then the matter would fall into the hands of the liquidators. They will then proceed with the liquidation pure and simple, and what will the shareholders then get? If they get 3d. or 4d. per share I think they would be lucky. Do not be deluded into the belief that you will get 2s. a share by dissenting from the scheme—an idea which is merely put before your eyes to damage the affair altogether. I regret that Mr. Abrahams is not here, because I had intended telling him, as the representative of Mr. Watt, that even if the scheme does not go through (I cannot believe, though, that the shareholders will be so blind to their own interests as not to carry the

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scheme)—if the Company falls into the hands of the liquidators to be dealt with finally—the matters between the Company and Mr. Watt will be carried through just the same as if the scheme is successful and the business goes on. He concluded by moving the resolutions as above, and added: Gentlemen, the agreement is here, and open to the inspection of any shareholder who wishes to see it. With your permission, however, we will take it as read, as it is a long document, and was fully read to the shareholders at the last meeting.

Mr. LOUIS SWABY, in seconding the motion, said: I think I ought to say a few words. Several shareholders have begged us, if the scheme put before you fails, to endeavour in other ways to carry on the Company. They are poor shareholders, and they have asked us to do all we can for them. The Directors have worked hard in support of your interests, and your interests alone, and I ask every honest man to back us up.

Mr. J. M. KLENCK: May I point out that this is our final scheme to you, and if you do not accept it the result will be that we shall go into liquidation, and you know the result of selling off our machinery, patents, and everything we possess, and what a small distribution that will give you. I think, however, that our Chairman has taken a rather gloomy view of the situation. A threat is one thing, but a fact is another. We hold these proxies from shareholders who are unable to attend, but who have sent them in our support, and we have not a proxy in the office dissenting from the scheme. I think the shareholders should know that, and that they should not follow those who are advising them, for their own reasons, to oppose the scheme, which is against the interests of the Company. I hope the shareholders will come into the scheme, and that in a short time we shall put the Company on a sound commercial basis—a position which it has not occupied for a long time in the past. We hope, however, that with your support we shall be able to put the Company on this commercial basis, so that we may take orders and execute them at a profit to the shareholders.

The CHAIRMAN then put the motion in the usual way, and announced that it was carried with three dissentients—Mr. Pankhurst, Mr. Robins, and Mr. Pates. He added: That, gentlemen, terminates the business we are met to transact. The forms of application for shares will be sent in due course to each subscriber; and, as Mr. Klenck says, I hope we shall find the shareholders support us in making application for the shares in the same way as they have sent in their proxies in support of the scheme.

A SHAREHOLDER suggested that with the application forms a report of the meeting should also be sent. Probably certain shareholders were dissenting to the reconstruction scheme in the belief that by not approving of it they would get 2s. a share, but if they understood what the only alternative was, as had now been placed before the shareholders by the Chairman, they might alter their present views.

The CHAIRMAN: I think it a very good suggestion that we should send the shareholders a *résumé* of what has taken place here to-day.

Mr. KLENCK: Now that the Chairman has left the chair, and before you disperse, I think it should be known to you that two of the three gentlemen who just now dissented from the resolutions are in the office of Mr. Watt; therefore, you know what their opposition comes from. I think it only right to communicate this to you unofficially, so that you may know what the opposition is worth. He afterwards added: I may mention that the three dissentients hold among them 50 shares.

The proceedings then terminated.

The Pilsen-Joel and General Electric Light Company (Limited).

An extraordinary general meeting of the above-named Company was held on the 4th inst., at the Cannon-street Hotel, under the presidency of Sir R. W. Rawson, K.C.M.G., C.B.

The SECRETARY (Mr. W. H. Trentham) having read the advertisement convening the meeting,

The CHAIRMAN said that the first business was to consider the resolution of which notice had been given, as follows:

"*That £100 each, free of income-tax, be paid to Messrs. Horace William Scriven and George Levinge Whately, in respect of their services as Directors of the above-named Company, from the 11th day of December, 1886, to the 13th day of March, 1888.*"

Most of the shareholders would remember the circumstances under which those gentlemen—it having been shown to them that by an oversight they had ceased to be qualified as directors—at once refunded the money they had received as members of the Board. As, however, he (the Chairman) stated in the circular which he had occasion to issue immediately afterwards, they were neither legally nor morally bound to have acted in such a generous manner, and he at the same time expressed a hope that the money would be refunded in due time. A shareholder had now come forward at the last stage of the Company's existence, being the opportune moment, to propose that the sum in question should be refunded. He (the Chairman) would be quite prepared to move the resolution himself, taking whatever obligation might be imposed on him for so doing, but as Mr. Gwynne, who was the largest shareholder in the Company, had come forward to propose it, he would leave it to that gentleman to move it, and he himself would be very happy to second it.

Mr. GWYNNE said that he had great pleasure in proposing the resolution, and as the largest shareholder in the Company the principal portion of the amount in question would come out of his share of the assets of the Company which might be distributed among the shareholders. When he made an offer to purchase the assets of the Company, he stated that it was his intention, as his first act, to refund the sum mentioned.

The CHAIRMAN seconded the motion, observing that Mr. Scriven and Mr. Whately were perfectly unconscious that they were unqualified by their holdings until the matter was pointed out to them at the time of the refunding of the sum in question. Nevertheless, they had done the work which they had to do as members of the Board.

Mr. J. A. FYFE objected to the money being repaid, on the ground that the gentlemen in question were not Directors at the time, and therefore ought not to receive Directors' fees; and, in the second place, he maintained that they did not deserve to be paid for what he termed their mismanagement. In his opinion they were not entitled to the money either legally or morally. He therefore strongly objected to the repayment, and added that the charges in his report (which he desired to read to the meeting) had not been answered. A large amount of stock was, he said, missing, owing to the culpable negligence of the Directors and the bad management of the managers.

Mr. GWYNNE protested that Mr. Fyfe was not speaking to the motion before the meeting, and he asserted that Mr. Fyfe had made statements which he knew to be untrue.

Mr. FYFE denied the assertion.

The CHAIRMAN said he should object to Mr. Fyfe reading his report, which had nothing to do with the motion before the meeting.

Mr. FYFE: You claim that certain money should be paid which I show by this report ought not to be paid, and is not due.

A SHAREHOLDER observed that that was the last opportunity which the shareholders would have, as a company, of ventilating their grievances, and everything ought to be allowed to be said that had to be said.

The CHAIRMAN: I wish to point out that these two gentlemen have been twice re-elected since.

Mr. FYFE: And have done exactly the opposite of what they were elected to do. Can the Secretary tell us about the stock sheets of 1884? Can they be found?

A SHAREHOLDER: That is not before the meeting.

Mr. FYFE contended that all these matters were before the meeting, and again inquired if the stock sheets could be produced.

Mr. STOBART protested against the repayment of the money referred to, that, he observed, being the only way they had of protesting against

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the mismanagement of the Company. £50,000 to £60,000, he said, had been wasted by the Directors, and the shareholders were now asked to pay a sum of money for neglecting their interests. The two gentlemen to whom it was now proposed to pay money had so much interest in the Company that they did not know whether they were Directors or not.

The CHAIRMAN: What Mr. Stobart has said is so far argument, if correct, but the fact is that this money was spent before Mr. Whately came on the Board; and, secondly, it was spent before the date for which it is proposed to pay these gentlemen this £100 each, and while the Company was under the management of Mr. Fyfe.

Mr. FYFE: I deny that.

The CHAIRMAN: £35,000 was spent while Mr. Fyfe was manager.

Mr. FYFE replied that he had left his stocks valuable, and the Directors, by their mismanagement, had allowed them to be stolen. They had been stolen and pawned, he added.

The CHAIRMAN: I deny that they were stolen or pawned. The goods were sold to the best advantage we could obtain.

Mr. A. HUTTON said he objected to the proposal on legal grounds. The notice stated that the money was to be paid to Mr. Scriven and Mr. Whately for their services as Directors, whereas they were not Directors at all at the time.

The SOLICITOR (Mr. Parker) stated that they were not qualified as Directors, but they did their duty as Directors, and it was for their services as Directors that the money was proposed to be paid to them.

The CHAIRMAN: And they were re-elected by the shareholders when they were in the same position.

Mr. GWYNNE: These gentlemen were not qualified for this reason: that owing to some alterations made at a previous meeting the nominal value of the shares had been reduced.

A SHAREHOLDER: They held double their qualification originally.

After some further observations from Mr. FYFE, who stated that the "game" from the beginning had been to dispose of the Company's property,

The CHAIRMAN put the motion, and stated that five had voted for it and six against it.

Mr. GWYNNE then demanded a poll, which was at once taken, at the close of which

The CHAIRMAN said the scrutineer (Mr. Gwynne) reports that the number of votes in favour of the resolution is 8,102, and the number opposed to it is 1,010. The resolution is therefore carried. We now proceed to the two resolutions which were agreed to by the requisite majority at the last meeting, and which now require confirmation. The first is:

"*That the Company be wound up voluntarily under the provisions of the Companies Acts 1862 to 1886.*"

Mr. WHATELY seconded the motion.

Mr. HUTTON proposed an amendment, adding to the resolution the words "under the supervision of the Court."

Mr. BROCKLEHURST seconded the amendment.

The CHAIRMAN stated that the proposal should have been brought forward at the last meeting; at the present meeting the resolution could only be accepted or rejected. He put the motion in the usual manner, and declared it carried by nine to four. Continuing, he proposed the next resolution, as follows:—

"*That George Shead, of No. 9, Laurence Pountney-hill, Cannon-street, in the City of London, chartered accountant, and William Henry Trentham, of No. 4, Stanhope-street, Euston-road, engineer, be and are hereby appointed joint liquidators for the purposes of such winding up.*"

Mr. WHATELY seconded the motion.

The CHAIRMAN put the motion, and declared it carried by seven to four. In announcing the close of the business of the meeting he stated that he had been on the direction from the beginning. He had worked hard, though he desired to say nothing about that; but he wished to express his sense of the courtesy and kindness he had received from the shareholders, and his regard for his colleagues. He wished also to express to his fellow shareholders—fellow sufferers with himself—his regret that, not through the fault of the Directors, but by the course taken with regard to them, they had been landed in a position not very different from most of the electric lighting companies, and with a less loss than most of them.

The proceedings then terminated.

NEW COMPANIES REGISTERED.

ELECTRO-GALVANIC MACHINE COMPANY (LIMITED).—This company was registered on the 1st inst. with a capital of £3,500 in £1 shares, to acquire the letters patent granted to John Douglas and Henry Abbott, for improvements in machinery or apparatus for producing and administering electric shocks and currents, and for exhibiting advertisements, dated 1st October, 1887, No. 13,326. Registered without special articles.

E. PAGE AND COMPANY (LIMITED).—This company was registered on the 28th ult., with a capital of £30,000, divided into 30,000 shares of £1 each, to carry on the businesses of an agricultural, mechanical, marine, and electrical engineer, and of an iron and brass founder and ironmonger in all its branches. To acquire the business now carried on by James Woodward Hill, trading as E. Page and Company, at Bedford, in the County of Bedford. There is not to be less than four nor more than six directors; qualification, 50 shares; the first directors are to be paid the sum of £50 per annum each, with an additional £50 for the chairman.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 4th, 1889, amounted to £3,755.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during December was 4,323, estimated to produce £3,500, against 3,925 messages, producing £3,373 in the corresponding month of last year. The traffic receipts for September, estimated at £2,700, realised £2,774.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of December were £1,908, against £2,004 in December, 1887, showing a decrease of £96.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of December, 1888, amounted to £59,831, against £57,703 in the corresponding period last year.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of December, 1888, amounted to £38,699, against £38,908 in the corresponding period last year.

EDISON-SWAN UNITED ELECTRIC LIGHT COMPANY.—In consequence of the alteration in the numbering of Victoria-street, Westminster, the address of this company will in future be 100, Victoria-street, London, S.W., instead of 13, Albert-mansions.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts for December, 1888, amounted to £22,000, and for the period from 1st January to 31st December, 1888, to £272,000. For the corresponding months of 1886 and 1887 they amounted to £258,600 and £264,480 respectively.

METROPOLITAN ELECTRIC SUPPLY COMPANY.—Application has been made to the Stock Exchange Committee to appoint a settling day in, and to grant a quotation to, the shares of the Metropolitan Electric Supply Company (Limited).

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended 31st December, 1888, amounted to £4,475.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 4th, 1889 (after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company), were £3,228.

NOTICE OF REMOVAL.—The offices of the Cuba Submarine Telegraph Company (Limited) have been removed to No. 58, Old Broad-street, London, E.C.

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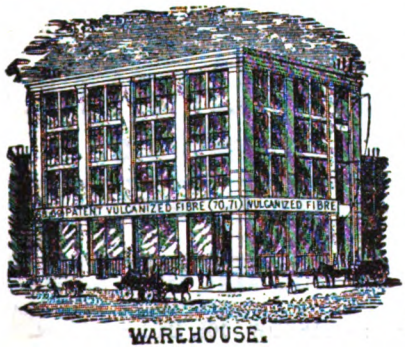

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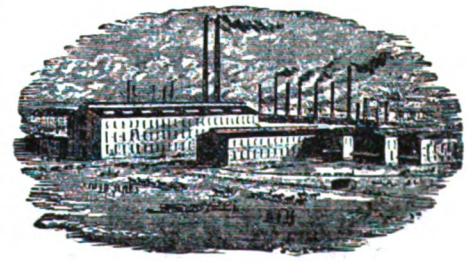
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Jan. 9, 1889.		Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Jan. 9, 1889.	
								Highest.	Lowest.
			TELEGRAPHS.			£ s. d.			
£ 1,770,360	Stock	7/6	Anglo-American	48	49	2 16 1	Jan., Apr., July, Oct.	48⅝	48½
2,614,820	Stock	15/0	Do. Preferred	80½	81½	3 7 6	,, ,,	81½	81½
2,614,820	Stock	nil.	Do. Deferred	16½	16⅝	...	February	17	15⅞
130,000	£10	3/0	Brazilian Submarine xd	13½	13⅝	5 3 8	Mar., June, Oct., Dec.	13 9/16	13⅜
112,900	£100	5%	Do. 5 per Cent. Bonds	101	104	4 16 2	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906) xd	106	109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14	14½	5 17 3	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18	19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3⅜	4½	3 15 4	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½	9½	5 5 3	April and October	...	...
60,710	20	2/0	Direct United States	9⅜	10	4 0 0	Jan., Apr., July, Oct.	9 1/16	...
380,000	10	2/6	Eastern	12⅜	12⅝	4 15 1	,, ,,	12 9/16	12 5/16
70,000	10	3/0	Do. 6 per Cent. Preference	14½	15	4 2 2	,, ,,	15	14⅛
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debentures	105	107	3 14 9	May and November.	106½	105½
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108	111	4 10 1	February & August	110½	...
250,000	10	2/6	Eastern Extension	12⅝	12⅞	5 1 0	Jan., Apr., July, Oct.	12¼	12⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	104	106	5 13 2	February & August	105⅜	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900 xd	101	104	4 16 2	January and July	101½	...
179,177	10	1/0	Globe Telegraph and Trust	6⅜	7	5 7 2	Jan., Apr., July, Oct.	7⅛	6 15/16
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜	14⅝	4 2 1	,, ,,	14⅝	14 7/16
150,000	10	5/0	Great Northern xd	14⅜	15	3 6 8	Jan., July, and April	15	14½
17,000	25	12/6	Indo-European	38	40	6 5 0	April and October	...	...
9,000	8	4/0	Reuter's	6½	7	...	April and October	...	...
15,609	10	3/0	West African Telegraph	7	8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	96	99	5 1 0	March & September	98	...
30,000	10	6/0	West Coast of America	9	9½	5 5 3	January and July	9⅛	9
150,000	100	8%	Do. Debentures 8% xd	117	121	6 12 3	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜	1 7/16	...	...	1 3/16	1⅛
34,563	10	12/0*	Do. 1st Preference 6%	11½	11⅝	5 2 2	April and October	11⅝	...
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½	12⅛	...	...	12 7/16	...
45,181	15	6/0	Western Brazilian	12⅜	13⅜	...	March & September	13⅜	13
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117	122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102	104	5 15 5	March & September	...	...
			TELEPHONES.						
224,850	14/0	5%	Consolidated Telephone and Maintenance	1/16	1⅛	...	Yearly	⅛	...
220,000	£1	2½%	Oriental (11s. paid)	1/16	1/16	...	...	...	...
80,000	5	5/0	United	14½	14⅝	5 5 3	June and December	14⅝	14
55,000	5	4/6	United River Plate	5⅜	5⅝	...	January and July	5 1/16	...
			ELECTRIC LIGHT.						
23,003	5	1/2	Anglo-American Brush (£4 paid)	3⅜	4½	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4⅜	5½	...	February & August	4⅞	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜	2⅝	...	...	2⅝	...
312,000	½	5% '86	Maxim-Weston	1/16	1/16	...	February	...	...
			MISCELLANEOUS.						
37,350	12	36/0	Telegraph Construction and Maintenance	40½	41½	5 15 6	March and July	42	41⅝
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	18½	19½	5 2 7	February & August	19⅜	18⅜

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 557.—Vol. XXII. FRIDAY, JANUARY 18, 1889. Price 4d.

NOTES.

The audience which assembled on Thursday evening last to hear Sir William Thomson's Address was probably the largest and was certainly one of the most enthusiastic and distinguished gatherings which the Society (or Institution) has ever witnessed. In the opening passages of the address, after paying a tribute to the memory of his predecessors, Sir William Siemens, Mr. Frank Scudamore, Mr. Walker, Colonel Champion, and Sir Charles Bright, who have passed away, the President referred in graceful terms to the addresses of Mr. Preece (1880), Mr. Willoughby Smith (1883), and Prof. Hughes (1886), who had each given expression to the keen desire for a mechanical explanation of electrical phenomena. To a masterly exposition of the results so far achieved in this direction the chief part of the Address was devoted. But before embarking upon this great—in other hands we might even say, perilous—undertaking, Sir William touched lightly upon several topics of lesser difficulty. Speaking first of the application of theory to signalling in submarine cables, he referred to his early researches, which proved that electro-magnetic induction did not need to be taken into consideration. But quite recently, within the last few weeks, Sir William has carried out an even more complete investigation of the problem, and has arrived at the result, also independently discovered by Mr. Oliver Heaviside, that in cable signalling "electro-magnetic induction is a positive benefit." Sir William dwelt for some time in terms of admiration on Mr. Heaviside's work, especially in connection with the telephone problem, which Mr. Heaviside has gone into very deeply. This led up to a brief consideration of the general problem of the distribution of periodic currents in conductors, with special reference to the conditions which prevail in the case of the currents used in the commercial distribution of electricity by means of transformers. In this connection information of great practical importance was imparted. Arriving now at the great questions of electro-magnetic theory and the relations of "Ether, Electricity, and Ponderable Matter," the President first expounded the analogy between the equations of motion of a viscous fluid—first given by Prof. Stokes—and the induction of electric currents, pointing out the failure which occurs in the endeavour to include a physical analogue of the electrostatic effect. From this he passed on to the "elastic solid" line of thought, reading a most interesting extract from a Paper which he had contributed to the *Cambridge and Dublin Mathematical Journal* forty-two years before. The problem therein considered has occupied his well-nigh unremitting attention ever since. Here he recorded his conviction in the words, "Whatever the current of electricity may be, I believe *this* is a reality, *it does pull the ether round.* I do not think this is a dream of electro-magnetic theory—I believe it to be a reality." He proceeded to show that if the effect consists merely in the rotation of the ether through a certain angle (corresponding to the current strength), so that a constant torque produces a constant angular displacement, and does not produce continued rotation, this could only be explained on the supposition that the molecules of matter possess inherent rotations of their own. This part of the subject was illustrated by some beautiful experiments with the gyrostat, and its curious behaviour was watched with the utmost interest. Sir William then explained and exhibited a model of his remarkable conception of the "molecular skeleton" framework of constant area. If a gyrostat could be placed in each cell, this would represent a medium possessing many of the most singular properties exhibited by the ether. Some further experiments with the gyrostat brought this memorable Address to a close.

If the electric dissipation of fog should prove to be practicable under open-air conditions, we shall next have to consider how far its realisation is a commercial possibility. And although this is, perhaps, running ahead a little faster than we have any actual warrant for, yet no harm can be done by hazarding the opinion that from this point of view the most promising—if not the *only* promising—method, would be the employment of high potential alternate-current transformers. A compound transformer, or battery of transformers, to give fifty or a hundred thousand volts, fixed on the top of the lamp-posts, and supplied with an alternating current from the regular service main, comes as near as anything we can at present see towards the realisation of Dr. Lodge's idea, although it must be admitted that high-potential transformers are likely to be somewhat expensive luxuries. The fog on December 31st, however, cost the Metropolis nearly £10,000 for gas alone—to say nothing of railway and street accidents, loss of time, loss of health, and general miseries—so that there really ought to be no difficulty in finding the money required for an experiment which is, to say the very least, not unpromising. In the case of fog, prevention is most emphatically better than cure, and if we can get rid of fog at the expense of a shower of rain, and at the same time reduce our gas bills, no effort should be spared to attain a consummation devoutly to be wished.

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MUCH as we may regret the withdrawal of the electric light from the streets of Leamington—a step on which the Town Council have finally resolved—yet we have from the first consistently deprecated the introduction of any system of low candle-power for street lighting. Holborn Viaduct, Pentonville-hill, Leamington—not to add Barnet—ought surely to teach the lesson that the public will inevitably denounce as a failure any electric light unless it outshines the gas to which they were previously accustomed. Let us hope, therefore, that we have heard the last of "experiments" of this character. We express this hope the more devoutly since we have an uncomfortable idea that it will shortly be falsified.

As for the Leamington Station, we do not imagine that the termination of the contract with the Council—which has yet twelve months to run—will be followed by a stoppage of the works. In a town like Leamington the loss of two or three hundred street lamps ought not to be a serious matter. So far as we are aware—and we speak in part from personal observation—there is no fault whatever to be found with the design or the working of the station other than the insufficiency of the public lighting. It is worth noting that great satisfaction was given by the Sunbeam Lamps which were in use for a short time, but the expense was too great to permit of their continuance. How it came to pass that the experimental trials of arc lighting proved so unsatisfactory we cannot explain. It is unfortunate that Messrs. CHAMBERLAIN and HOOKHAM were unable to satisfy the no doubt somewhat fastidious tastes of the local big-wigs, but that arcs *can* be made to burn steadily is certain.

THE "Notes on the Design of Electric Motors" which were read by Mr. A. T. SNELL before the Old Students' Association at the Central Institute on Wednesday evening deserve attentive consideration on the part of all who are interested in this important branch of electrical engineering. It will be seen that Mr. SNELL maintains the view that although the comparison of dynamos and motors does not necessarily present any marked difference of design, yet in many cases a sound method does entail actual structural differences, even to the extent of producing a machine which, though good as a motor, may prove inferior or even bad as a dynamo. (Mr. SNELL does not, however, suggest, as certain flippant wits have phrased it, that the worse the dynamo the better the motor.) The point of departure which he recommends to be taken in the construction of a motor is *torque*, and not horse-power, whilst the speed is made a coefficient to determine the horse-power. The motor should, then, be designed so that the average maximum torque falls on a certain part of the characteristic, usually near the top of the straight limb. This can be attained by paying attention primarily to the armature alone, the field being designed at a later stage. The impressed E.M.F. is not an important factor in the general design. The factors by which the torque is determined are only in number—namely, the current, the number of wires on the outside and the resultant magnetic lines through the armature; but experience alone can show in what way these three factors can best be adjusted in order to fit the motor to the work for which it is intended.

PROJECTS for constructing an underground railway from the City to the West End by way of Holborn and Oxford-street have often been under consideration; but few of them have been so promising as the one which now occupies the field, and which not improbably will be submitted to Parliament in the ensuing Session. This is for an electric railway just below the surface of the roads, avoiding the main drains, and commanding easy access by a few steps from the footpaths. The scheme is threatened with a stout opposition on the part of the shopkeepers, but chiefly for reasons which would apply to all swift means of transit along their line of route. In constructing the subway room will of course be provided for laying electric light cables, as well as water-mains and gas-pipes, so that the scheme presents several collateral advantages. If properly engineered it should present every prospect of success.

THERE was once a German professor who, at the dinner of a learned society, gave as a toast "The Theory of Numbers, the only branch of Mathematics which can never be degraded to the service of Physical Science;" and at the next meeting of the society a Paper was read "On the Application of the Theory of Numbers to the Determination of the Nodes of Vibration of Thin Plates." This story may, perhaps, be paralleled in the history of the gyrostat, which no one would have supposed capable of lending itself to directly utilitarian ends. If there is any truth in the statement that it is capable of superseding the mariner's compass, probably the next information upon the subject will come from Mr. H. EDMUNDS; at any rate we are justified in denouncing that gentleman as the *fons et origo* of the rumour.

WE have received the following communication from a correspondent:—"The Electrolunatic presents his compliments to the Editor of *The Electrician*, and begs to inquire why at the Symphony Concerts at St. James's Hall they run the electric lamps, 170 in number, red-hot all the time that the gas is in full blaze; and whether the expense of the dozen horse-power thus wasted in warming the air of the hall falls on Mr. HENSCHEL or on the Grosvenor Gallery Company."

THE conflict between the Continuous and the Alternating Systems has been renewed with increased vigour in the States. In a long letter to the *New York Times* Mr. GEORGE WESTINGHOUSE, jun., makes some sharp comments on the recent experiments of Mr. HAROLD P. BROWN, at Edison's laboratory, Orange, N.J.; asserting that Mr. HAROLD P. BROWN is not seeking for truth, but is looking after the imperilled interests of the Edison Company. Mr. WESTINGHOUSE is not content that the alternating-current system should be considered as safe as its rival, it is much safer; "the alternating current is less dangerous to life, from the fact that the momentary reversal of direction prevents decomposition of the tissues." To this onslaught, Mr. HAROLD P. BROWN has replied by a challenge to a duel *à l'outrance*. Mr. WESTINGHOUSE is to take a current alternating 300 times a second through his body, and Mr. BROWN will do likewise with a continuous current; the pressure is to begin at 100 volts

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and increase by 50 volts at a time; each contact is to be made for five seconds, and the battle is to go on until one or the other has cried enough. All this is, no doubt, excellent fooling, but has little or nothing to do with the question at issue, which is simply whether the dangers of high tension currents are so great and of such a nature as to warrant the enforcing of precautions which would practically amount to prohibition. This question, we take it, is satisfactorily answered by our own experience of alternating-current distribution from the Grosvenor Gallery, as well as by the enormous and increasing growth of the Westinghouse Company in America. Even Mr. HAROLD P. BROWN, we should think, must at heart accept the deductions he would have us draw from his experiments with several reservations, in the face of such a remarkable manifestation of public favour.

Sofia.—Plans and estimates are wanted for the lighting of Sofia by electricity. Proposals will be received by the Mayor up to May 1st.

Electro Harmonic Society.—In another part of our columns will be found the programme of the smoking concert of the Electro Harmonic Society.

Cardiff. — The whole of the electrical apparatus for the Christmas pantomime at the Cardiff circus has been supplied and run by Messrs. Sydney F. Walker and Olliver, of Cardiff.

Crompton and Co.'s Calendar.—A handy office accessory has been issued by Messrs. Crompton and Co. (Limited) in the shape of a combined blotter, calendar, diary, and address book.

"Electric Power."—We have received the first number of *Electric Power*, a new monthly journal, published in New York, and devoted to the interests of the electric railway, and of the transmission of power by electricity.

Swansea.—It is announced that the Swansea Harbour Trust, who have for some time lit the Prince of Wales Dock by electric light, are about to extend the system over the whole of the docks, wharves, warehouses, sheds, and offices under their management.

The Fire at the Melbourne Exhibition.—It is satisfactory to learn that the small fire which occurred in the Vienna court of the Melbourne International Exhibition, and which was at first reported to be due to an accident to an electric lighting lead, proves on further inquiry to have arisen from the use of a methylated spirit lamp.

Royal Society.—Dr. Gore read a Paper yesterday (Thursday) before the Royal Society on "The Relative Amounts of Voltaic Energy of Electrolytes;" and Prof. J. J. Thomson read a Paper on "The Resistance of Electrolytes to the Passage of Very Rapidly Alternating Currents, with some Investigations on the Times of Vibration of Electrical Systems."

The Metropolitan Board of Works.—The Metropolitan Board having been communicated with by Messrs Latimer Clark, Muirhead and Co., on behalf of the St. James and Pall-mall Electric Light Company (Limited), the clerk was requested to write to the company stating that the Board had no objections to the proposal of the company to lay electric lighting mains in Duke-street, St. James's, and certain other places in the neighbourhood. Permission was given to the London Electric Supply Corporation (Limited) to lay a main for conveying electricity through part of the Victoria Embankment Gardens east of Charing-cross Bridge.

The Anglo-Belgian Telegraphs.—The *Moniteur* recently published the Anglo-Belgian Telegraph Convention, which refers to the expiration of the concession to the Submarine Telegraph Company. No concession is to be granted to private persons. The two existing cables between Middelkerke and Ramsgate and La Panne and Dover are to be taken over by the two countries, and, if necessary, three new cables, each with four conducting wires, are to be laid. The rate for ordinary telegrams is to be 2d., or 20 centimes per word, and the returns are to be divided at the rate of 11·25 centimes for England and 8·75c. for Belgium. The sums received for transit telegrams are to be divided equally.

Electric Lighting at the House of Commons.—An extension of the system of electric lighting is in progress at the House of Commons. Hitherto the only portions of the building so lit have been the division lobbies and upper corridors, the library, reading room, tea room, smoke room, and a limited number of other apartments, but when the House re-assembles it will be found that gas has also been superseded in the cloak rooms and entrance lobbies, and on the main staircase. It is understood that this is the first step towards the general adoption of electric light at St. Stephen's, and that before long the oil lamps used in the committee rooms will be abolished, and electricity substituted for gas in the public corridors and waiting halls as well as in the members' lobby.

Obituary. — The death is announced of Sir William O'Shaughnessy Brooke as having occurred at Southsea, after a short illness. The late Sir William was born in 1809, consequently he was in his 80th year. He graduated M.D. at Edinburgh University, and subsequently entered the Bengal Medical Service as Assistant Surgeon in 1833, was appointed Surgeon in 1848, and Surgeon-Major in 1861. He was appointed Superintendent-General of Telegraphs in India in 1852, but resigned in 1862, and retired from the Indian Medical Service. He was the author of numerous works on scientific and engineering subjects, particularly one on the electric telegraph, published in Calcutta in 1839. He was knighted for his services in establishing the electric telegraph throughout India, and was a Fellow of the Royal Society.

The Thomson Effect.—M. A. Battelli has recently been pursuing some investigations with regard to the Thomson effect. The method employed was similar to that of Le Roux, but more accurate. These investigations show that, so far as the metals experimented on are concerned, the quantity of heat carried by the current is proportional to the strength of the current, and that, except for iron, it is proportional to the absolute temperature. If in the formula $\epsilon = a\,T\,i$, i is expressed in C.-G.-S. units, T in absolute temperature, and ϵ in calories, the value of the constant a for the different metals experimented upon will be as follows:—

Cadmium	$a = 3{\cdot}678 \times 10^{-8}$
Antimony	$a = 7{\cdot}081 \times 10^{-8}$
Bismuth...	$a = -3{\cdot}909 \times 10^{-8}$
German silver	$a = -2{\cdot}560 \times 10^{-8}$

Montreal.—The city of Montreal is supplied with the electric light by the Royal Electric Company, and a rather singular scale of charges is employed. For lighting residences the rates are—$8 per annum for first lamp, $7 per annum for second lamp, $6 per annum for third lamp, $5 per annum for fourth lamp, $4 per annum for fifth lamp, $4 per annum for sixth lamp, and $2 per annum for each subsequent lamp. The net effect of this sliding scale may be shown as follows:—5 lamps cost $2.20 per month, being an average of 50c. each; 10 lamps cost $3.42 per month, being an average 34c. each; 15 lamps cost $4.25 per month, being an average of 28c. each; 20 lamps cost $5.08 per month, being an average of 25c. each; 25 lamps cost $5.92 per month, being an average of 24c. each; 50 lamps cost $10.08 per month, being an average of 20c. each. Reception rooms are supplied with 16 candle-power, and other rooms with 10 candle-power lamps, no distinction in this case being made in the charges. But lamps of 16 candle-power are substituted for those of 10 candle-power where desired for $1.50 extra, and 25 candle-power for 16 candle-power for $5 extra per annum. The company have 425 arc lights, equal to 850,000 candle-power; also 20,000 incandescent lights in operation.

The New "Subject Matter of Patents" Index.—A correspondent writes:—"Who on earth is responsible for the idiotic subject-matter index of complete specifications advertised as accepted during 1888? It appears to be compiled with the express view and object of befogging and bewildering the unhappy searcher. Take any subject you like to search in—say, 'Incandescent Lamps.—Section II. of Electric Lamps.' Here is a copy: 'Filaments (including attaching to terminals), '87; 4,116, 4,549, 7,042, &c.' 'General Construction of, '87, 4,116, 4,549, 11,802,' and nine other numbers. 'Shades.—*See* Lamp

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Shades.' Of what use, as an intelligible and useful index for searchers, is this? Every single specification under the number has to be turned up and examined. Absolutely no information is afforded, as used to be the case, as to whether a dynamo, a transformer, or a switch be included in the patent application. What unnecessary labour this system involves! Searching is a laborious business now; but what will it be in future years if this system is persevered with?"

Light Motors for Aeronautic Experiments.—M. Trouvé has constructed several small and extremely light motors of the Gramme and Siemens type, in order to carry out some aeronautic experiments. One of these motors, while only weighing 90 grammes, is capable of developing ·026 brake horse-power. All the parts of the machine are of aluminium with the exception of the magnets. This motor, which could be contained in a box of three centimetres side, is able to lift itself 22 metres in one second by means of a wire and a fixed support. A one horse-power motor constructed on the same lines would weigh barely 3·5 kilos. When furnished with a light screw and attached to the arm of a balance, the motor is able to lift its whole weight when connected to a constant source of electrical energy equal to 40 watts. In order to facilitate his experiments M. Trouvé places his motor at one end of a long lever capable of vertical and horizontal movement about its centre, the electrical connections being made with the motor through the lever and its supports.

The Telephone in Switzerland.—The returns published by the Swiss Confederation with reference to the development of telephonic communication in Switzerland show that, since the establishment of the first telephone in 1880, sixty-one towns have been provided with it, and there are now 6,944 telephonic stations, of which no fewer than 1,500 are in Geneva and its suburbs. Most of the Swiss towns are now connected with one another, Geneva communicating not only with Lausanne and other places on the shores of the lake, but with Berne, Zurich, and St. Gall. The Confederation has taken over the telephones, which are attached to the Department of Posts and Telegraphs, and the annual cost of subscription is only £6. Notwithstanding this moderate charge the receipts exceed the expenditure by about £8,000, and the Federal Council now contemplates reducing the rate of subscription to £5 for the first year, £4 for the second, and 80f. for the following years, with a trifling supplemental charge for those subscribers who use the instrument more than 500 times during the twelvemonth.

Westminster.—At a meeting of the St. Margaret's and St. John's (Westminster) Vestry, the Works and General Purposes Committee reported that they had before them a proposal by the Kensington Court Electric Lighting Company, offering, with a view to the general adoption of electricity in place of gas in the more important thoroughfares of the Knightsbridge district, to light up the lamps at Hyde Park Gate for one month free of charge, after which period they would be prepared to enter into an arrangement for the permanent supply of current to these and other lamps which the Vestry might decide to have so lighted. The cost of the lighting would be based on the experiment. The committee recommended that the application be granted, subject to the company holding the Vestry harmless against any loss or expense, and on the direct understanding that they were not committed to the continuance of the light. Provision should also be made for the company to light the gas in the lamps in the event of the electricity failing. The report and recommendation were agreed to.

Wrought-Iron Belting.—Mr. John Spiers, of Worcester, Mass., gives the following interesting particulars of the successful adoption of wrought-iron belting:—"A lathe used for turning rolling-mill rolls, compound gear, has a 48in. pulley. This is driven by an 18in. pulley on the countershaft, which makes 120 revolutions per minute, and is 8ft. from the 48in. pulley, measured from centre to centre. Both pulleys are of iron smoothly turned on the faces. A 7in. double leather belt was used in these pulleys, but would slip when the turning tool became dull. This belt was replaced by one made of Russian sheet iron, the same as that used for stove-pipes and parlour stoves, and was riveted together in the ordinary way. It was 7in. wide and 2in. longer than the leather belt the extra length making up for the want of elasticity in the iron. During one year's steady run this iron belt could not be slipped, even when a heavy cut on a 25in. roll was taken, which broke a Sanderson steel tool, having a section of 12in. by 2½in., a cutting surface of 2½in., a feed of ⅛in. per revolution, and an overhang of 4in."

The Electric Light at Leamington.—The Leamington Town Council resolved on the 14th inst. to give the Midland Electric Light Company twelve months' notice to determine the contract for lighting the streets of Leamington by electricity on the ground that it had been a failure. Two months ago Messrs. Chamberlain and Hookham initiated experiments with 36 candle-power incandescent lamps, the "Sunbeam" and the arc system. The last-named, though the cheapest, has been dismissed owing to the flickering and unreliable nature of the light. Nothing is said against the "Sunbeam" lamp but its expense, as it would entail an annual outlay of £900 for lighting the principal streets of the borough. The gas company offer to light the same area with Sugg's "Whitehall" lamps for £300 per annum. The local papers say that the townspeople very much regret that the spirit and enterprise displayed by Messrs. Chamberlain and Hookham has not been attended with better success, and do not relish the prospect of having to go back to gas—a necessity which seems forced upon them by economic considerations.

Morecambe.—At a meeting of the Morecambe Local Board the clerk said he had received a letter from Mr. Darlington, solicitor, Bradford, on behalf of Messrs. Andrews and Preece, asking whether the Board proposed to oppose their application for a Provisional Order to supply electric lighting within the district. A gentleman handed him (the clerk) a notice on 29th October, stating that on the expiration of six weeks the promoters intended to apply for the order, but according to Act of Parliament the notice must be given in July, and all advertisements issued in October or November. It was impossible for anything to be done under that notice. It was also quite clear that the Board would not assent to an application before they saw plans and particulars of the scheme. In the short discussion that followed the Chairman remarked that the Board were and had been for some time considering the question of supplying electricity themselves. He thought the manner of the present application rather a singular one, and that it looked as if it was not a very strong company. It was ultimately decided that until plans and particulars of the scheme were submitted the Board could not take any action in the matter.

Electricity in Mines.—At the Veteran Mine, near Aspen, Col., there is a complete electric installation, driven by a water-power generating plant. A Pelton wheel is operated by water from a flume 70ft. above, the flume being 20in. diameter, with a 3in. discharge nozzle; the volume of water thrown against the wheel is regulated by a governor, according as the strain is given or slackened by the engineer a mile and a quarter distant A 500-volt dynamo is used, and a Sprague motor of 10 to 15 horse-power. The motor is located in a chamber 1,000ft. long in the mine. The engineer has the usual brake on the hoister ready to his right hand, while with his left he turns a small switch to start, stop, or reverse the motor, or to regulate the speed. In addition to the hoist, the motor pulls in the loaded or empty cars, and controls the speed of all the trains on the tramway and in the tunnel. The entire train is sent out and returned in eight minutes, and twenty cars can be handled rapidly and continuously if necessary. The motor utilises about seventy per cent. of the power from the water wheel. The working is very economical, and there is no trouble from noise, &c., with the motor in the tunnel. This plant has been in use for some months, and a duplicate plant is to be put to work extensions of this mine and the Franklin Mine.

Electric Meter Competition in Paris.—The following are the terms of the electric meter competition, which is to take place under the auspices of the Paris Municipal Council:—1. The instruments submitted to the committee may be either for continuous or alternating currents. Generally speaking every instrument will be admissible which is intended to measure electric energy under any form whatever. 2. The competitors

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may suppose that only the difference of potential or the strength of the current is varied, or that both are varied. They may therefore send in ampere-hour meters, volt-hour meters, or watt-hour meters. 3. The meters must, above all, be suited to a small consumption; they ought to be able to measure the energy furnished to a single 10 candle-power lamp. 4. For alternating currents, the same conditions hold good; but attention should especially be given to the construction of watt-hour meters, which alone give exact results in inductive circuits. 5. The instruments will be submitted to comparative tests as to (*a*) proportionality and accuracy at every output; (*b*) the energy wasted in effecting the measurements; (*c*) the disturbance caused by using the instruments; (*d*) the practical value of the instruments (simplicity, cost, regulation). The five members of the jury appointed by the Municipality are MM. Mascart, Hospitalier, Vaillant, Lyon-Alemand, and Pottier.

Strand District Board of Works.—At the last meeting of this Board the Lighting Committee reported that they had considered applications for Provisional Orders from the Metropolitan Electric Supply Company (Limited), London Electric Supply Corporation (Limited), House-to-House Electric Supply (Limited), Electrical Power Storage Company (Limited), and from the Westminster Electric Supply Corporation (Limited). They (the committee) considered that the two first-mentioned companies only were in such a position as would render it prudent for the Board to enter into negotiations with a view to one or other, or both, of such companies supplying electricity to the district. The first-named company, the Board, by the adoption of one of the reports of the committee, had already viewed with some favour; but with reference to the second, it appeared to feel strong enough to carry the Provisional Order it had launched, and therefore was not prepared to make any arrangements with or concessions to the Board. They recommended, however, that the clerk should be directed, in conjunction with the Parliamentary agents, to present objections to the Board of Trade against the granting of Provisional Orders to all the above-mentioned companies. Dr. Sandwell, in moving the adoption of this report, said it was only a preliminary report of the committee, who would further consider the matter in the course of a few days. The report and recommendations were adopted.

A New Method of Tracing Curves by Photography.—In a recent number of the *Bulletin of the Académie des Sciences de Belgique*, M. Eric Gérard describes a new method of automatically registering observations by means of photography. In some of his researches into the nature of alternating currents, M. Gérard obtained very good curves by using a delicate dead beat galvanometer. A beam of electric light was reflected from the galvanometer mirror through a lens, falling finally on to a sheet of sensitive paper. After some trouble very good results were obtained in this way, but not being completely satisfied, he cast about for some other method of obtaining the same end. M. Gérard's new arrangement consists of a moderate-sized Ruhmkorff coil, the spark from the secondary coil of which plays between a piece of aluminium wire and the point of an arc lamp carbon. The two electrodes are fixed at least one millimetre apart. The spark is projected on to the movable mirror, and thence to the sensitised paper, which may be wrapped round a drum, or, more conveniently, simply stretched on a frame, which can be allowed to fall between guides. The period of the sparks depends solely on the elasticity of the spring of the vibrator of the primary coil, and the number of spots photographed in unit length of the curve on the sensitised paper forms a convenient time scale. By connecting the electrodes of the secondary coil to a couple of small Leyden jars, a very short and white spark is obtained, the position of which is invariable. This plan has the advantage of reducing the dimensions of the numerous spots which make up the curve photographed.

Italian Telegraph Statistics.—On the 30th June, 1887, the length of the Italian telegraph lines amounted to 32,768 kilometres, the length of wire being 113,046 kilometres, an increase over the preceding year of 2,195 and 4,138 kilometres respectively. The offices opened for the service of the public during the period 1886-87 were 244, of which 160 are worked by the Administration, and 84 by the railway and tramway companies. The total number of offices open for the service of the public on the 30th June, 1887, was 3,374, of which 2,192 were Government and 1,182 railway or tramway offices. The apparatus in use in the Government offices increased during the year by 210, reaching a total of 3,485. The number of inland and foreign telegrams dealt with in the period 1886-7 was 8,844,015, an increase of 510,716 compared with the period of 1885-6. The private inland telegrams forwarded both by the Government offices and by the railway offices were 7,024,614, showing an increase of 333,226 over the preceding period. Forwarded and received foreign telegrams increased in 1886-7 by 148,365, reaching a total of 1,492,215. As for Government telegrams, the total of the previous year was slightly increased. The ordinary receipts of the Administration were 13,888,670 lire (£555,547); and the ordinary expenditure 11,113,053 lire (£444,522). The net profit was therefore 2,775,617 lire (£111,025). This profit would be reduced to 1,125,881 lire (£45,035), if we deduct the value of the chargeable Government telegrams, which amounted to 1,649,736 lire (£65,989). The total value of franked Government telegrams would have been 811,286 lire (£32,451), and was less by about one-sixth than that of the preceding period, 1885-6.

Barney's "Make and Break" Telephone.—From a pamphlet which has been sent us by Mr. W. C. Barney we extract the following description of his improvements on the Bourseul telephone. We may add that Bourseul's instrument was referred to in the judgment of the Supreme Court of the United States (*The Electrician*, April 6th, 1888, p. 609) in terms which leave it to be inferred that the principle is outside the Bell patent. Mr. Barney describes his latest telephonic achievement as follows:—"These instruments are very simple improvements on instruments invented by Bourseul. The description published in 1854 is in the following words:—'Suppose a man speaks near a movable disc sufficiently flexible to lose none of the vibrations of the voice, at each of the vibrations the disc touches a small point placed in front of it, and this contact suffices to throw the current into the line. The improvement consists in placing a point on each side of the disc so that the contacts will be made at each half vibration of the disc, instead of at each full vibration, as in Bourseul's transmitter. Bourseul's receiver is described in the following words:—'At the extremity of the line the current enters an electromagnet, which attracts another vibrating disc of size and quality identical with the former; attracted and repelled very rapidly, exactly, and as rapidly in fact as the disc above mentioned, this second disc gives forth a sound, which will have the same musical value as that of the other disc, as the number of the vibrations per second is the same in both cases.' The improvement consists in substituting for the soft iron core of the electromagnet a steel core magnetised. The Supreme Court of the United States says:—'The method of Prof. Bell consists in creating changes of the intensity of a continuous current or flow of electricity in a closed circuit.' Barney's system consists in the use of intermittent pulsations of electricity in contradistinction to undulatory currents, whereas Bell's system, the Supreme Court says, 'consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current.' Numerous crucial tests by eminent practical scientists, made solely in the interest of science, have demonstrated that when the circuit is closed on the right-hand side, varying from the most delicate contact to a firm contact, no sound whatever can be heard in the receiver, and when the circuit on the left-hand side is closed with a delicate contact, a series of ticks only is heard; and when the circuit is closed firmly no sound is heard in the receiver; and when both circuits are closed at the same time, varying from the most delicate to a firm contact, no sound is heard in the receiver; when the electrodes are not in contact articulate speech is reproduced in a clear, loud, and distinct tone. It is, therefore, evident that Barney's instruments do not operate with an undulatory current in a closed circuit, which is the essence of Bell's system." The improvements described were patented by Mr. Barney in the United States on February 8th, 1887, and August 21st, 1888."

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 272.)

The screening action of metallic masses has been well demonstrated in certain investigations by Prof. D. E. Hughes in carrying on some highly valuable experimental researches into the means of preventing induction upon lateral telegraph wires.* It has many times been proposed to annul mutual induction between telegraph and telephone wires by covering them over with thin metal covering, which covering is kept "to earth." It is now known, and well exemplified in Prof. Hughes's experiments, that this shielding affords no protection when the covering is not very thick and when the rate of change of the currents is not very rapid. A gutta-percha wire was enclosed in ten coverings of tinfoil, and such arrangement was not found to afford protection to induction, as detected by a telephonic wire stretched alongside. Even when twenty coatings of thin charcoal iron were put round the wire, not only was there found to be a very sensible permanent field outside the iron, but changes of field were made manifest also. It is not to be taken that these experiments invalidate the fact of magnetic screening, but only that the low conductivity of the envelopes used is ineffective at the speed of current change employed to render visible the effect of magnetic screening. It is different, however, if the inductive effects are being produced by a *very rapid rate* of change of field. For suppose that a small circuit as before is placed in a uniform field, and traversed by q lines of induction due to this external field. Suppose q varies according to a simple periodic law, so that $q = \mathrm{Q} \cos p t$, where $p = 2 \pi n$, n being the frequency of the alternations. Then we have

$$-\frac{dq}{dt} = \mathrm{Q}\, p \sin p t\,;$$

but $-\frac{dq}{dt}$ is the value of the impressed electromotive force in the circuit, and if we call the current at any instant i, then, by the principles in Chap. III., we have

$$i = \frac{\mathrm{Q}\, p}{\sqrt{\mathrm{R}^2 + p^2 \mathrm{L}^2}} \sin (p t - \theta),$$

in which R is the resistance and L the inductance of the circuit, and

$$\theta = \tan^{-1} \frac{\mathrm{L}\, p}{\mathrm{R}}.$$

Suppose that R is very small compared with $\mathrm{L}\, p$, which is the case when n or the frequency of alternation is made very great, then R vanishes compared with $\mathrm{L}\, p$, and if we call i'' the value towards which i approximates in this case, we have

$$i'' = -\frac{\mathrm{Q}}{\mathrm{L}} \cos p t,$$

and

$$\frac{di''}{dt} = \frac{\mathrm{Q}}{\mathrm{L}} \sin p t,$$

or

$$\mathrm{L}\frac{di''}{dt} = \mathrm{Q} \sin p t = -\frac{dq}{dt}.$$

Hence

$$\mathrm{L}\frac{di''}{dt} = -\frac{dq}{dt},$$

or

$$\mathrm{L}\, i'' + q = \text{constant}.$$

Hence the field due to the current in the circuit, together with the external field, is a constant quantity, and we get the condition of perfect shielding. We may sum up the foregoing by saying that if a screen of absolutely no electrical resistance is interposed between a primary and secondary coil, it effects a perfect magnetic screening, whatever may be its thickness. If, on the other hand, the screen has a finite conductivity, then the screening will be very imperfect, unless a very great thickness of material is used, and the above will be true when the change of field or the change of primary current is a simple "make" and "break" or a slowly periodic change. When, however, the change of current in the primary is *very* rapidly periodic, then the screening effects of even imperfect conductors will make themselves felt, and a comparatively thin screen of metal will effect a nearly perfect shielding for induction. This theory is strikingly confirmed by some very beautiful experiments of Mr. Willoughby Smith, which are described in the *Journal* of the Society of Telegraph-Engineers (November 8, 1883, Vol. XII., p. 458), and entitled "Experiments on Volta-Electric Induction." Mr. Willoughby Smith's apparatus consisted of two flat coils A and B (*see* Fig. 21), placed a certain distance apart. One of these was a primary coil connected with a battery, and the other was connected with a sensitive galvanometer. In the circuit of both were current reversers, which reversed the galvanometer and battery alternately, and hence made the

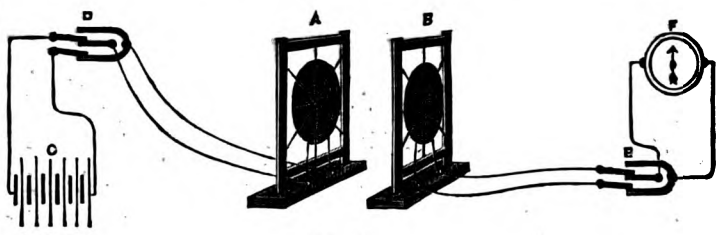

Fig. 21.

opposite induced currents both affect the galvanometer in the same direction. This being arranged, the commutator was started so as to reverse the currents very slowly, and a sheet of copper interposed between the spirals. Under these circumstances the interposition of the copper produced but little effect. If, however, the commutator was driven at a very rapid rate the copper plate caused a marked diminution in the galvanometric deflection, and this diminution was greater in proportion as the speed was greater. For the original Paper a curve is given (Fig. 22) which shows the decrease in the galvanometer deflection, expressed as a percentage of the original undiminished deflection, corresponding to various

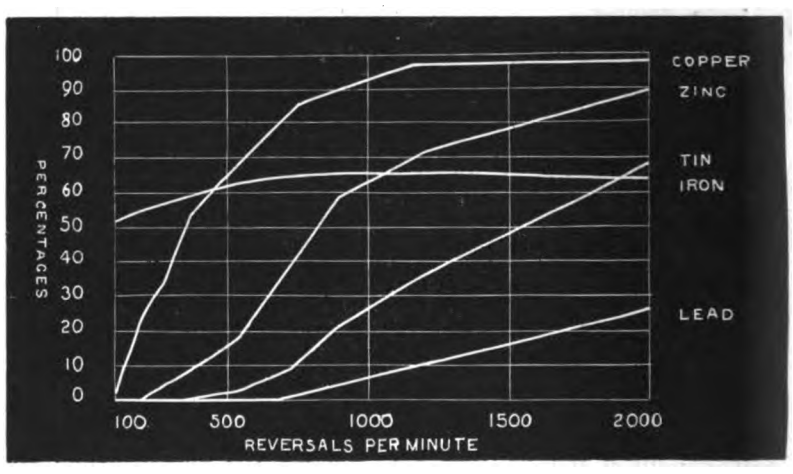

Fig. 22.

speeds of reversal. It will be seen that the *less* the conductivity of the metal the *greater* must be the speed in order that the magnetic screening may approach perfection. Iron, of course, occupies an exceptional position. It cuts off, even at very low speed reversals, a large portion of the field, not by a true screening action, but by conducting away the lines of magnetic force and preventing their access to the secondary coil. It will be seen that at any given speed the order in which the metals reduce the deflection is the order of their electric conductivity, and that as far as the diagram goes the lines all (except iron) slope upward, indicating that at very high speeds the screening of even the worst conductors will approach perfection. It would no doubt be found that if

* *See* a Paper by Prof. Hughes "On Lateral Induction in Telegraph Wires," read before the Soc. Tel. Eng., March 12, 1879.

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the telephone were used as a detector that the magnetic screening of a copper plate or thin tinfoil sheet would become very manifest for high notes when not in any way marked or distinguishable for notes or sounds of low frequency of vibration.*

As far back as 1840 Dove had made experiments† on the effect of the introduction of cores of various materials into the primary circuit of an induction coil. His apparatus consisted of two similar primary bobbins wound on tubes of non-metallic substance and connected in series (Fig. 23). Over each primary bobbin was wound a secondary circuit, and these secondary circuits were connected in series, but so that the induction of the two primary bobbins operated in opposite directions and nullified on the whole secondary circuit each other's effect. Exact neutralisation was obtained by adjusting one of the secondaries. When this was the case various cores of iron rods of different kinds were inserted in one primary bobbin, and it was found that the induction balance was destroyed. By inserting iron wires of a certain size in the other core, balance could be again obtained, but not simultaneously, as estimated by the galvanometer and by the shock. Thus, with a bar of forged iron 110 wires had to be inserted in the other coil to obtain an equilibrium, as estimated by the galvanometer; but as far as could be judged by the shock 15 wires were sufficient. With regard to different kinds of iron, experiment shows that if we class them according to galvanometric effect we obtain a different series to that at which we arrive when classifying them in the order in which they create sensation by shock. Thus grey rough cast-iron is the kind which approached nearest to bundles of soft iron wire in respect of increasing the shock. Enclosing iron wires in a brass tube reduced the action of the wires in disturbing the inductive balance and rendered them very little better than a bar of solid iron. When the primary current was a discharge from a Leyden jar, Dove found that the physiological effect (shock) of the secondary current, as estimated, was reduced by the introduction into the primary bobbin of non-magnetic conducting cores; in other words, the introduction of a core of non-magnetic but highly conducting material into the primary bobbin reduced the power of a primary discharge to create a secondary discharge. These last results may be obtained in a more modern form by the substitution of a Bell telephone, to detect the tertiary currents generated by the metal core.

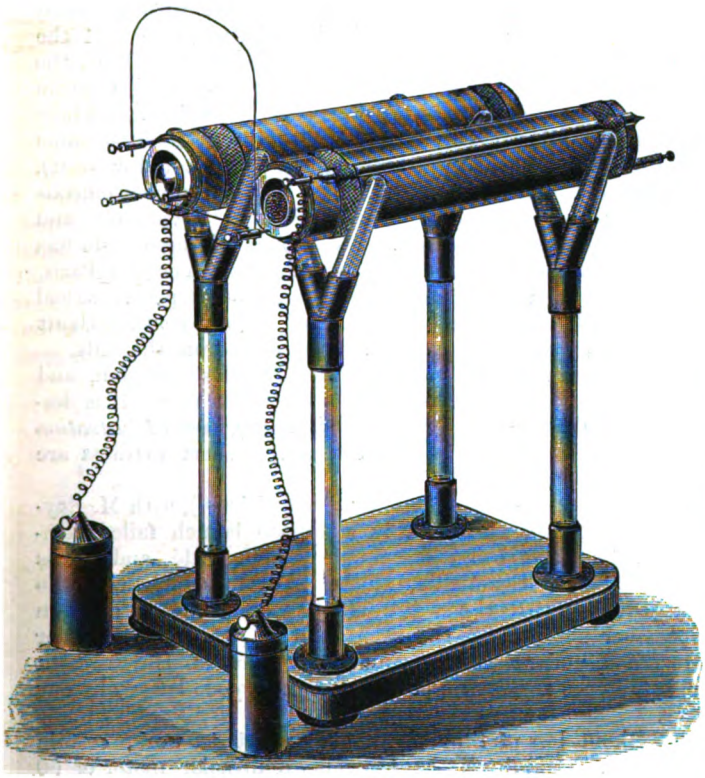

Fig. 23.

Let a Bell telephone be connected in series with the secondary coil of a small induction coil, of which the primary is wound on a hollow bobbin, and the frames are wholly of wood or non-metallic substance. A convenient form is that known as Du Bois-Reymond's sliding coils. Let an interrupter in the primary circuit make and break the circuit rapidly. This being so, the telephone emits a steady rattle or hum. If a massive copper rod is introduced into the primary bobbin as a core, the telephonic rattle is more or less suppressed; if a core of soft iron wires is introduced the noise is increased; if a core of solid iron or steel is used the noise may be increased, but not so much as when the divided iron is used. The explanation of the exalting effect of the soft iron wire is simple. The presence of the iron reduces the "magnetic resistance" of the circuit of magnetic induction due to the primary current. More lines of induction therefore flow through the secondary circuit, and hence the strength of the secondary current is increased, and the rate of change of induction through it is also increased. The diminishing effect of the copper core is explicable by the light of the knowledge that in such a conducting core the primary current generates induced currents, and these in their turn re-act upon the secondary circuit, inducing in it a tertiary current. The direction of the currents induced by the primary in the solid core and in the secondary circuit are the same. The direction, however, of the first half of the tertiary current developed in the secondary by the current in the copper core is opposite to the direction of the current developed in the secondary by the action of the primary. Hence it results that the

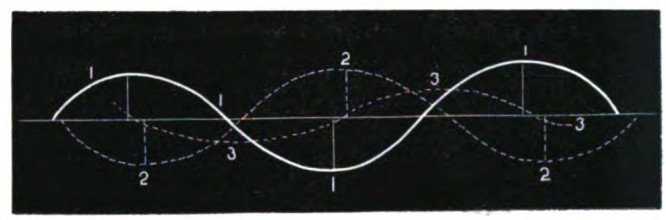

Fig. 24.

current in the secondary circuit is more or less wiped out by the opposing inductions due to the primary circuit and the currents induced in the copper core. Otherwise the operation might be regarded thus:—Suppose the primary circuit to be traversed by a periodic current creating a simple periodic flux of induction through the copper core. As we have seen under the head of magnetic screening, this variation of induction would induce currents in the copper core which would themselves generate a flux of induction, which would, if the conductivity of the core were perfect, or the rapidity of change of induction infinite, be exactly equal and opposite at each instant to the flux of induction producing those currents.

If the conductivity is not quite perfect, or the rate of variation not very great, yet nevertheless the direction of the field of magnetic force inside the copper, due to the currents induced in its mass, will more or less oppose the field of force at every instant which is by its fluctuations generating those currents. If the thick line 1 1 1 in Fig. 24 represents the sinusoidal or simple periodic change of induction or magnetic field in the interior of the copper, due to the primary helix, and if the dotted line represents roughly the changing field due to the eddy currents generated in the core, which are nearly 180° behind the primary in phase, the integral or sum of both superimposed fields at any instant is less than the original one due to the primary alone at the corresponding instant. Also the *mean rate of change* of the resultant field is less, and the secondary circuit experiences at every instant a less inductive electromotive force. The same reasoning which we have employed in the case of magnetic shielding applies here, and the differences in the reducing effect of cores of various metals would be found to be less at high speeds of

* The above explanation of the cause of the difference between the screening of the different metals is not that given by the distinguished investigator, but it is the explanation which to the author seems most in accordance with known principles.

† Dove, Poggendorff's *Annalen*, Vol. XLIX., 1840

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alternation than at low. In some small induction coils used for medical purposes the strength of the secondary current is graduated by drawing in or out of the primary coil a copper tube which slips over the bundle of fine iron wires used as a core. The *rationale* of the action of this copper tube in so operating is in a rough general way to be found in the principles laid down above.

(To be continued.)

ALKALINE ACCUMULATORS AND THE "GYMNOTE" SUBMARINE TORPEDO BOAT.

BY P. B. ELWELL.

To invent a reversible couple, or secondary battery, with iron, copper, or carbon plates in an alkaline solution has been the aim of many electro-chemists ever since Planté gave to the world, in his modest, unostentatious way, the first so called accumulator. The advantages of a light and strong metal for the plates, a solution nearly neutral when in a state of discharge (for transport at ordinary rates), and non-injurious to adjacent metal work, having no fumes of any kind, and the use of sheet iron cell, or tin box, being alone of sufficient attraction, without considering the possibility of attaining a higher rate of discharge without injury and a greater amount of energy stored per pound of cell.

But, although many attempts have been made, nothing of any practical value appears to have been reached until, in 1886, a French engineer, M. Dezmazures (who, together with his chemist and electrician, M. Commelin and his associates, MM. Virloy and Bailhache, had been trying all possible combinations with more or less—but never any complete—success, mainly for want of a negative plate that would freely absorb the oxygen of the charge and give it back in the discharge), bethought himself of first obtaining *a perfectly non-coherent mass of pure metallic copper* by electrical reduction from the oxide, and then compressing it in a steel mould to the extent of some thousand atmospheres by means of a hydraulic press.

On immediately carrying out this idea they found that by nothing but an enormous pressure it was easy to make a pure copper plate of equal strength and hardness to rolled copper from the loose reduced metallic "mud." Then, by regulating the pressure so as to produce an *apparently* solid copper plate, but in reality of only about two-thirds the specific gravity of rolled copper, and consequently *infinitely porous*, a beautiful negative plate was produced. I use the term "beautiful" in a literal sense, for every one who sees these plates with their planished surface of shining copper cannot but admire them. This plate was found to possess the properties required—perfect depolarisation and very low electrical resistance. It was then only a question of finding a suitable solution from which a metal could be alternately deposited upon the positive plate and redissolved.

Research having already been made in this respect, it was an easy matter to test the most favourable results in combination with the new negative plate, and the following general construction has been finally adopted, with certain modifications when used for special purposes. A copper negative 2 to 3 millimetres thick, enclosed in an envelope of parchment cloth (ordinary parchment paper being liable to get torn by rough handling), opposed to an iron positive plate of wire gauze, in a solution of zincate of potassium of 50deg. Beaumé, the whole contained in a thin sheet-steel tinned box. An extremely strong light and serviceable cell is thus obtained. During the charge the zinc is deposited upon the iron gauze plate and the superfluous oxygen is absorbed freely by the copper plate. In the discharge the zinc is re-dissolved, combining again with the oxygen from the copper plate. It will be thus seen that there is no reason why the plates should in any way suffer, and it is found, after the considerable experience referred to below, that whilst the iron plates remain absolutely unchanged, the copper plates actually become harder and stronger by long use.

These cells give a comparatively low E.M.F. and a very large quantity of current, and where small "quantity" only is required the cells may be made up in cases of three, one of such boxes measuring 10in. by 4½in. by 10in. (high), and weighing 28lb, giving a discharge of 150 ampere-hours, at from 2·70 to 2·05 volts, according as the rate of discharge be slow or rapid. This division into three cells for each box is very favourable in preventing "swilling" where much knocked about.

A discharge may be made in as little as 2½ hours with fair efficiency and perfect safety to the plates, and for sudden efforts —such as are required for tramway work—a current of 200 amperes may be obtained without injury from a cell weighing 19lb. (This was actually shown by Messrs. Sautter, Lemonnier, of Paris, when they kindly lent a battery of these cells to the Académie des Sciences for illustrating the "Cowles" aluminium process.) The cell may be completely sealed up for portable work, and when used for stationary purposes the solution may be covered by a film of oil to prevent the formation of carbonate and "creeping" up the terminals.

The notice of the French Government experts was early drawn to this invention, and in the Spring of 1887 a battery of 132 cells, weighing 40 pounds each, was ordered for a large steam launch. This launch was thoroughly tested at Havre in the following months of September and October, with the result that the naval authorities ordered a large battery of 560 of the same cells (9¾ tons) for the new submarine torpedo boat, the "Gymnote," then being designed by M. Zédé and Captain Krebs. (Meanwhile a few tests were carried out in London, where an electric omnibus was driven by 14cwt. of these cells at the same speed as 28cwt. of the most approved lead cells could drive it). This battery was tested at Havre by the Government officials previously to its installation on board the "Gymnote," and accepted as most satisfactory. An account of these tests was read by M. Mascart, before the Académie des Sciences at Paris, and showed a total weight of 37 kilogrammes per electrical horse-power-hour, and an efficiency of 65 per cent., without including a residual charge afterwards taken from the cells.

The "Gymnote" was not launched until last autumn, and the trials did not take place until a few weeks ago. It is described in *La Nature* (December 22nd, 1888), and *l'Illustration* (December 8th, 1888), from which a few short extracts are translated as follows:—

"A first attempt, in November, 1876 (? 1886), with M. Reynier's accumulators installed in a torpedo launch failed completely. Without being discouraged, MM. Zédé and Krebs applied to MM. Commellin, Bailhache and Desmazures, who had just invented the light alkaline accumulator, and on September 20th, 1887, the same boat in which M. Reynier had failed, underwent the triumphant trials at Havre which resulted in the acquisition of the electric torpedo launch by our navy.

"Without loss of time the engineers set to work, certain of success. Captain Krebs built his multipolar motor of 60 horse-power. M. Zédé entrusted M. Romazzetti, Naval Constructive engineer, with his plan of the 'Gymnote,' which was laid down in the Toulon Arsenal, and MM. Commelin and Desmazures proceeded with the construction of the giant battery of 564 accumulators, to have a capacity of 93 million kilogrammetres (345 horse-power-hours). The much-regretted M. Desmazures died very suddenly last January, but M. Commelin, assisted in a patriotic manner by Madame Desmazures, was well able to finish his part of the work. The 'Gymnote' is propelled by a powerful 4-blade screw 1·50 metre in diameter. The motor is Captain Krebs' invention. It has 16 poles arranged round a ring armature one metre in diameter, furnished with a commutator and four brushes, two for going ahead and two astern.

"The speed is 200 revolutions per minute, and the propeller is driven directly. The motor weighs 2,000 kilogrammes and gives 60 horse-power with the normal current of 220 amperes at 220 volts.* The electrical energy is provided by the battery of 564 alkaline accumulators, completed by M. Commelin. Each

* This is the French cheval-vapeur = 735 watts, and the armature resistance only has apparently been allowed for. The *actual* efficiency at *200 revs.* does not exceed *80 per cent.*

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cell weighs 17·5 kilogrammes, making a total weight of 9,840 kilogrammes. Taking the total capacity of 345 horse-power-hours, the weight per horse-power-hour stored is 28·6 kilogrammes. This allows for a speed of 10 knots for six hours.

"The trials at Toulon were begun in the Vauban Dock, and continued in the open sea. They surprised, beyond measure, the few privileged spectators. The boat manœuvered like a fish, on the surface as well as below, and maintained the desired depth with precision at all speeds, changing direction, and taking up the position ordered, with great facility. We cannot speak too highly of the complete success which has crowned the efforts of MM. Zédé, Krebs, Commelin and Romazzetti, who may be proud of their work."

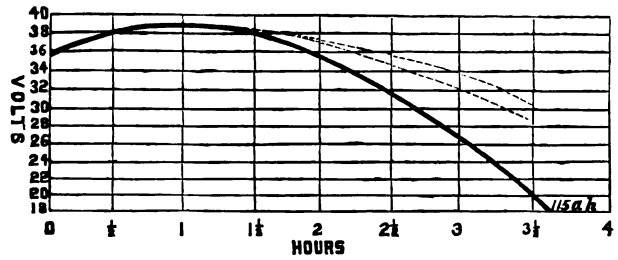
But the most favourable and important field for the use of these cells—where the very shaking to which they would be subjected would be most advantageous—is the traction of tramcars and vehicles of all kinds running on paved roads. For this purpose, the lightness, strength, and durability under great varieties of discharge, coupled with absence of fumes to corrode machinery, are a very great consideration, and steps have already been taken with a view to using the accumulators on the Paris Tramways, where something will probably be done in time for the opening of the Exhibition.

"Diagram of Two Discharges.

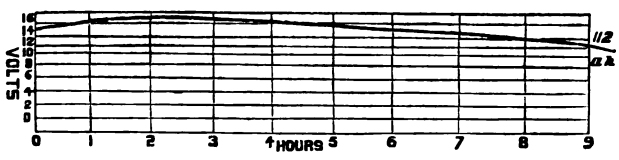
Cell measuring 6 inches by 3¼ inches by 6 inches outside.

Weight of box and solution	6lb.
Total weight of plates, copper and iron	3 ,,
Total weight of cell	9lb.

"Charge: 10 amperes for 12 hours at 1 volt (average E.M.F.), solution zincate of soda 45deg. Beaumé. Discharge through a constant resistance of ·0017 and ·0066 ohm respectively. These figures are to be considered approximate only, the measuring instruments not being so delicate as could be desired, but as one of the first experts of the day is about taking exact tests such data will soon be available.



The dotted lines give an idea of the improvement caused by agitation of the solution during discharge.



"The above diagram shows two idiosyncratic curves of discharge, one at a very high rate and the other at a normal rate. The peculiar rise in E.M.F., especially remarkable in the case of the heavy discharge, may be accounted for partly by the decrease in internal resistance caused by the solution rising in conductivity as it increases in density and partly by the rise in temperature having a similar effect, much more noticeable in the curve of rapid discharge.

"The great question of a perfect miner's lamp has occupied the attention of those connected with this new accumulator, and by substituting a thin plate of silver—made by the same process—for the copper plate, an increase of about 100 per cent. is obtained in E.M.F. Consequently, the "silver cell" only weighs about half the copper one for a given output.

"For a miner's lamp the battery with silver negative plates only weighs 3lbs. for 50 watt-hours, and of this weight not more than ½lb. would be silver—always preserved in its metallic form, with no waste or deterioration in value—the cost of which is thirty-two shillings; but as the process of manufacture actually raises the value of the metal by purification (it is the same in the case of copper, and a point of great importance), this outlay in silver is not a costly matter, 4 per cent. per annum covering wear and tear, depreciation and interest."

THE INSTITUTION OF ELECTRICAL ENGINEERS.

SIR WILLIAM THOMSON'S PRESIDENTIAL ADDRESS.

The Institution met on Thursday last at the Institution of Civil Engineers, the retiring president, Mr. E. Graves, at first occupying the chair.

After formal business had been transacted,

Mr. Graves announced that the last legal steps had been taken in reference to the name of the Society, and that in future "The Institution of Electrical Engineers" would take the place of the old name in all documents.

The Secretary (Mr. Webb) then read the following letter from Prof. Silvanus Thompson, to whom had been awarded the Society's premium:—

"20, Arundel-gardens, 15th December, 1888.

"Dear Mr. Webb: I am in receipt of yours of the 14th inst. announcing that the Council of the Society of Telegraph-Engineers and Electricians have awarded to me the Society's "Premium" for 1888. I need not say that I gratefully acknowledge the honour which the Council have done me in selecting me to be the recipient of this award. I should value highly such an addition to my library, and deeply appreciate the expression of the Council's goodwill.

"That the original intention of the Society in establishing this premium was to offer it for the encouragement of the efforts of the junior members of the Society is, however, obvious.

"And I, having already once served on your Council—namely, in 1886—and having just been again elected, cannot but feel that, though technically I may be entitled to the honour, the interests of the Society will be best served if the Council will revert to the original intention of the award.

"I therefore ask the Council to allow me most respectfully to decline the premium.

"Believe me, dear Mr. Webb,

"Yours very truly,

"Silvanus P. Thompson."

Mr. Graves said they could hardly fail to appreciate Prof. Thompson's motives (hear, hear). The recommendations of the Premium Committee of the Council were that that gentleman having declined to receive the prize awarded to him, the gentleman named for the second prize should receive the first, the gentleman named for the third should receive the second, and the gentleman who was highly commended should receive the third (applause).

Mr. Graves then presented the first and second prizes to Mr. A. C. Cockburn and Mr. Edward Stallibrass respectively, and stated that as Mr. E. O. Walker, to whom the third premium had been awarded, was in India, his wishes as to the form in which he desired to receive it had not, of course, been yet ascertained.

The retiring President then vacated the chair in favour of

The President (Sir William Thomson), who was received with loud applause.

Sir Wm. Thomson then delivered the following Presidential Address on

"Ether, Electricity, and Ponderable Matter."*

Gentlemen: My first duty is to give you my warmest thanks for the great honour you have done me in electing me to be the first President of the Society of Electrical Engineers. Fourteen

* As Sir William Thomson has been good enough to undertake the revision of our report, we are in a position to publish only the first portion in the present issue

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years ago, when the three-year-old Society of Telegraph-Engineers honoured me by appointing me to be their President, the Society numbered 570 members; it now numbers 1,550 (hear, hear). It is gratifying to us to think how that young Society has grown and how successful it has been.

But while we think with pleasure of the great increase of our numbers, that pleasure is saddened by the thought that a great many of the old members, are gone, and especially the first two presidents—Sir Wm. Siemens and Mr. Frank Scudamore. The genial presence of Sir Wm. Siemens is a happy recollection to many of us—I think I might say to nearly all present—and the thought that he is no more with us is certainly a very great grief to all who have known him, and a loss to science and to England. We look back upon Mr. Scudamore's presidency with great satisfaction, considering all that he did for the Society, and his loss is deeply felt. Three of the presidents since I had the honour to serve are also gone—Mr. Walker, Col. Champain, and, within the past year, Sir Charles Bright. The first Atlantic cable of 1857 gave me the happiness and privilege of the acquaintanceship with Sir Wm. Siemens. In the course of the work, Sir Charles Bright was my colleague. He was engineer to the company, and during the thirty-three days when we were out of sight of land in the ever-memorable "Agamemnon" expedition of 1858, Sir Charles Bright was with us, full of vigour and enthusiasm. To his vigour and earnestness and enthusiasm in a great measure was due the existence of that cable, the temporarily successful cable of 1858, and all the great consequences which followed from it, even although that cable itself had a very short life, having only three months of working time, and a still shorter time of really useful, practical work. Still, we must always feel deeply indebted to Sir Charles Bright as a pioneer in that great work, when other engineers would not look at it, and thought it was absolutely impracticable; and we must always look upon our late colleague, lost within the last year, as having done much indeed for the subject of the Society of Telegraph Engineers (applause).

The Society of Telegraph-Engineers has grown not only in membership, but in the extent of its province from the time of its foundation until now. It became the Society of Telegraph-Engineers and Electricians a few years ago, and now the more properly representative title of the Institution of Electrical Engineers has been adopted. The original name included only telegraphy, but that was not then the only application of electricity to engineering. There was electro-metallurgy. Electro-metallurgy and telegraphy were the two, and I think the only two, branches of practical science to which electricity had then been applied; but since that time we have a vast augmentation of the field. We have telephony; we have electric transmission of power. The Society of Telegraph Engineers will recollect Sir William Siemens's introduction to it of that great subject of the electric transmission of power on a scale of practical usefulness. I think we may safely feel that to the Society of Telegraph-Engineers in a large measure is due that practical development of electricity. We have now power electrically transmitted through factories to drive separate machines by separate motor dynamos. We have electric haulage and electric tramcars. We have the application of electricity to naval and military purposes; and last, not least, we have the application of electricity to electric lighting. With all these grand subjects of applied practical science for our province, I think the Institution of Electrical Engineers may feel that it has a great and noble dominion.

But we must not forget that the province of the electrical engineer necessarily touches upon that of the civil engineer. When fourteen years ago I gave my inaugural address, I endeavoured to impress upon engineers and architects that architects made a great mistake in not being engineers, in not qualifying themselves as engineers, and doing the work of engineers; that architects do not do their duty to their clients in not being engineers and understanding the engineering of their own works, and making engineering science, particularly the dynamics of engineering, an essential part of the training of an architect. It is not necessary to make any animadversion, I think, upon electrical engineers in this respect. Electrical engineers know well that they must before all be engineers (hear, hear). They must be engineers, and they must learn electricity.

To young persons who have a taste for electrical machines (and who that is young has not a taste for electrical machines, and sparks, and flashes, and aurora borealis artificially made, and the smell of ozone—sulphur and phosphorus we used to call it!—which is one of the pleasing reminiscences of one's youth in working with electrical machines?) a word of advice may be useful. Every young person who has a fancy for electricity thinks he would like to be an electrical engineer. They think electrical engineering is all ether and electricity. Now, I have continually to impress upon anxious fathers and mothers that their boys must condescend to learn something of gross ponderable matter, and that electrical engineering is not confined to ether and electricity, but mechanics also is an essential part of the subject. It is, I think, an important practical point this—that the electrical engineer, or the youth or aspirant to that honourable profession, ought to learn mathematics and dynamics after having obtained the elements of a good general education. He ought to learn mathematics and dynamics well. Then a good deal of chemistry and regular mechanical and civil engineering should all be learnt; and electricity learnt besides. It may be said juvenile life is too short. I do not think it is. I think if the other subjects are well learnt electricity may be learnt in a few months. I am perfectly sure that if the youth is qualified in other departments, the mere addition of electricity to the education of a competent engineer will not take so very long a time as might be imagined (hear, hear), and that the merely educational part of the work will not be protracted unduly by adding electricity to the branches learnt in general engineering. I do not mean to say that if electrical engineering is the branch adopted there is not an endless and prodigious field of electricity proper in which the worker will learn every day of his life, though he lives for more years than any person present. I wished just to make these few remarks in the beginning, because they do seem to me of some practical importance, and worthy, therefore, of being put in the front of the address I have to offer as first President of the Institution of Electrical Engineers.

Now these remarks have suggested to me a subject for such a scientific exposition as I could possibly attempt to give in this opening address—ether, electricity, and ponderable matter. The demand for something like a mechanical explanation of electrical phenomena is not new, but it is growing in intensity every year. The proceedings of recent meetings of the British Association—and especially of the last meeting of the British Association—illustrate the growing desire to know something below the surface; to know something of the internal relations connected with the wonderful manifestations of force and energy which are put before us in the action of the magnet, in the working even of a common electrical machine and in electromagnetic phenomena. The addresses of Past Presidents of the parent Societies of Telegraph-Engineers and Telegraph-Engineers and Electricians illustrate also the growing desire to know something of the molecular theory or the dynamical theory of electricity and magnetism. Mr. Preece, in his address of 1880, pointed out how Maxwell had shown the velocity of light to be related to electricity in such a way that we can scarcely doubt but that the propagation of electromagnetic disturbance through space, which we have every reason believe does exist—which, in fact, from known laws we may say certainly does exist—is effected with a velocity equal to that of light, and that the propagation of electrical disturbance and of light may perhaps be identical. In support of these remarks, Mr. Preece alluded to the disturbances at the sun's surface and the simultaneous magnetic disturbances which had been observed in the telegraphs and in other operations of an electro-magnetic character on the surface of the earth.

In 1883 Mr. Willoughby Smith described shortly some experiments which I consider to be very beautiful and very instructive with which he was then engaged. Those experiments demonstrated and illustrated the screening effect of sheets of different kinds of metal upon electro-magnetic and electro-static inductions. Electric induction, simply, we may say, because we begin to fail to distinguish between electro-static

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induction and electro-magnectic induction. In Willoughby Smith's subsequent work he gave an exceedingly beautiful set of experimental investigations of the screening effect of lead, copper, and iron, of which, as I have said, a slight sketch was given in his Presidential Address. A little earlier the subject was mathemetically worked out with great power by several mathematicians, but perhaps most notably by Horace Lamb. I feel it almost invidious to mention names when there are so many thorough workers who touched upon the same subject very closely. Charles Niven,* almost simultaneously with Lamb,† went through very much the same kind of work—in fact, obtained the same solutions of some important and interesting problems regarding electric currents in spherical conductors. I specially mention Lamb's name because the subject of screening is more particularly developed in his mathematical Paper.

In the memorable Presidential Address of Prof. Hughes, another allied branch of electro-magnetic induction was very admirably illustrated by experiments which are now more or less familiar to us all (hear, hear), but which have been of an immensely suggestive and stimulating character, both to mathematicians and to experimental workers. The very criticisms by mathematicians upon some of the experiments and modes of statement by Prof. Hughes have, with Prof. Hughes' own experiments, given a very large body of electric knowledge and electro-magnetic knowledge, which, without such stimulus and such mathematical and experimental scrutiny as it has led to, might have been wanting for many a year (hear, hear).

One of the earliest problems in which electric induction had to be considered was that of the submarine telegraph. The subject of induction in telegraph wires presented itself in a peculiarly perplexing way to the first workers in that department. There was the general knowledge of electro-magnetic induction between two wires, which had been worked out by Henry and Faraday in a very full manner. That was the only kind of induction which was thought of by some of the pioneers of submarine telegraphy. Another kind of induction was more thought of by others. That was the electrostatic induction due to the Leyden-jar charge of the insulated wire. Faraday, in this department, as in the other department, was the origin of nearly all that we now know. He explained in a very beautiful and clear way the electrostatic charge of the submarine cable, and showed how the electricity conducted through the cable from one end, to give what of potential is necessary in the middle or the other end of the cable—in the middle of the cable for any mode of working, at the other end of the cable for modes of working in which the other end is insulated—gave rise to the Leyden-jar charge. He pointed out (without going into any of these details, however), the doctrine of the conduction of electricity through the wire to supply the Leyden jar charge, which the wire must have, in the course of working, in order to be raised to the difference of potential from the earth required to cause the signal current to pass through it. Cromwell Varley made very important advances in that direction. At the meeting of the British Association in 1854 at Liverpool, he brought forward some important developments of Faraday's doctrine. And then came on the great Atlantic Cable question. I always remember how that question came upon me. I see in Prof. Stokes's presence with us this evening a reminder of the circumstances. I was hurriedly leaving the meeting of the British Association when a son of Sir William Hamilton, of Dublin, was introduced to me with an electrical question. I was obliged to run away to get to a steamer, by which I was bound to leave for Glasgow, and I introduced him to Prof. Stokes (applause), who took up the subject with a power which is inevitable when a scientific question is submitted to him. He wrote to me on the subject soon after that time, and some correspondence between us passed, the result of which was that a little mathematical theory was worked out, which constituted, in fact, the basis of the theory of the working of the submarine cable. In that theory electro-magnetic induction was not taken into account at all. The leaving it out of account was justified by the speed of signalling, which the circumstances of a cable exceeding 200 or 300 miles in length dictated. For a cable more than 200 or 300 miles long the speed of working was essentially limited by these electrostatic considerations—limited so much that the electro-magnetic induction certainly could have no sensible effect. But the possible speed of working in a cable of 20 miles or 50 miles, or even 100 miles, was so great that in short lengths like that, the electro-magnetic induction might well come into play. I worked out the subject partially myself. I found it necessary to do so to satisfy myself that the doctrine upon which the Atlantic cable project, then growing up, was ultimately founded, was thoroughly trustworthy. I found it necessary to investigate the question of electro-magnetic induction. This question was further forced upon me by communications that I had with my friends, Lewis Gordon, and the two brothers, Charles Wm. Siemens and Werner Siemens, with reference to Mediterranean cables. It was imagined that electro-magnetic induction alone was operative—that embarrassment in working through the submarine cable was due to electro-magnetic induction alone. On its being demonstrated that electro-magnetic induction could have no sensible effect on the signalling through proposed Mediterranean cables, the proposal to have two thin wires close together in order to obviate electro-magnetic induction was given up. Experiments in Germany had shown considerable electro-magnetic induction on short lengths of cable, and it had been supposed that there would be embarassment from this cause in the working of the cables, which would be diminished by using wires very close together. But this diminution of the electro-magnetic inductive influence would produce a corresponding increase in the electrostatic inductive influence; and when it was pointed out that the electro-magnetic inductive influence would be absolutely imperceptible at the highest speeds of working of the proposed cables, and that it would be the electrostatic induction which would limit the speed, the idea of making them of thin twin wires—two pairs of wires close together in metallic circuit—was given up, and the present type of submarine cables was adopted. But now it is very interesting to us to find that old question revived. I had myself laid it aside in some corner of my mind and in some slight corners of my note books for forty years. Within the last forty days I have really worked it out to the uttermost merely for my own satisfaction. But in the meantime it had been worked out in a very complete manner by Mr. Oliver Heaviside (applause), and Mr. Heaviside has pointed out and accentuated this result of his mathematical theory—that electro-magnetic induction is a positive benefit, it helps to carry the current. It is the same kind of benefit that mass is to a body shoved along against a viscous resistance. Suppose, for instance, you had a railway carriage travelling through a viscous fluid. Take a boat on wheels so that the more massive body will not sink deeper in the fluid than the less massive body. Take a boat on wheels in a viscous fluid. We will shove off two boats with a certain velocity—the boats of the same shape; but let one of them be loaded to ten times the mass of the other—it will take greater force to give it its impulse, but it will go further. That is Mr. Oliver Heaviside's doctrine about electro-magnetic induction. It requires more electric force to produce a certain amount of current, but the current goes further. It is a very crude way in which I am putting it. I am not doing justice, of course, I know, to his statement in one short sentence. The whole question is treated in the most complete mathematical way. The effect of electro-magnetic induction and electro-static induction taken together (and they cannot be separated) is fully worked out. One thing that was known of old is made a point of in Mr. Heaviside's treatment of the cable problem; that is, the beneficial effect of leakage in respect to clearness of signals. Old telegraphists remember that. They always used to say three or four good leaks in a cable, if they would but kindly remain constant, and not introduce extra trouble by earth currents, would make the signalling more distinct. That used to be well known, and the reason used to be fairly well known; mathematical theory had pointed it out. Now Mr. Oliver Heaviside has taken up

* "On the Induction of Electric Currents in Infinite Plates and Spherical Shells," *Phil. Trans.* Roy. Soc., 1881, p. 307 (read Jan. 29th, 1880.)

† "On Electrical Motions in a Spherical Conductor," *Phil. Trans.*, Roy. Soc., 1883, p. 519 (read April 5th, 1883.)

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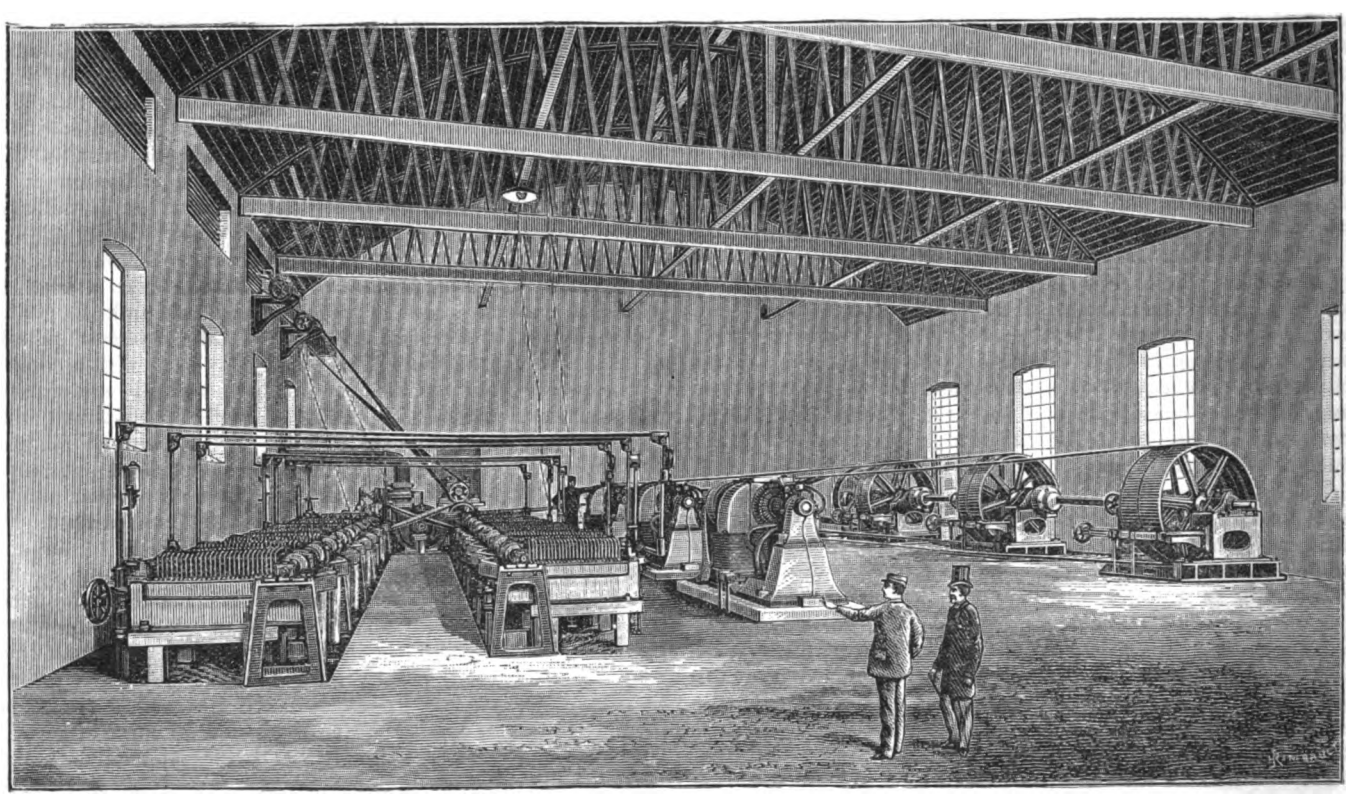
that subject again and included it in his work. He has included it along with electro-magnetic induction, and this point he has particularly accentuated. It is a practical point of imimportance that the question of clearness of signals is not simply or even very importantly this—how much is the current attenuated at the remote end of the cable? how much is the amplitude of the electric current in one mode of working, or of the variation of electric potential in another mode of working, altered in transmission through a thousand miles or two thousand miles of cable? A certain range is given at the sending end; and what is the range at the receiving end? That is an important question, but it is not the most important question with reference to clearness of signalling; in fact, we might almost say it is not an important question at all. It is not the smallness of the signals at the receiving end that is the real difficulty in a submarine cable just now at all; it is the running of one signal into another; it is the want of correspondingly definite distinctions of single signals or of a group of signals at the receiving end and at the sending end.

Now, in the mathematical theory there are two things to be considered in respect to the distortion (as Heaviside called it) of the signals in passing through the cable. One thing to be considered is the retardation of phase; another is the diminution of amplitude. If the retardation of phase was the same for alternating currents of all periods, then this retardation of the phase would be of no consequence whatever—it could not diminish the distinctness at all. Again, if the diminution of the amplitude was precisely in the same proportion for alternating currents of all periods, then when we come to make non-periodic signals we should find that the signals would be transmitted with perfect sharpness. In fact, if we compare the transmission of electric signals through a wire with the transmission of sound through air, we have in the course of transmission of sound through air great attenuation by distance, inversely as the square of the distance in fact, but the same for all notes; and again retardation of phase depending upon the velocity of the sound, the same for all notes. The result is that speaking, and musical performances, and signals of all kinds in air lose none of their clearness by distance. It is just a question whether at the very greatest distance at which a sound can be heard there is any want of clearness due to different attenuations of the different notes or of the different elements forming the compound sound, or to difference of retardations of phase. I must not occupy you too long with this subject, but it is one of large practical importance. Heaviside points out that electro-magnetic induction causes a less great difference in the attenuation of different periods than there is without it; and that electro-magnetic induction (as we knew forty years ago) tends to reduce the retardation of phase to the same for all different notes—that is, to the retardation equal to what would depend on a velocity not very different from the velocity of light if the signals have but sufficient frequency. That velocity was then and is still known as the velocity which is the conductance in electrostatic measure, and the resistance in electro-magnetic measure of one and the same conductor. But its relationship to the velocity of light was brought out in a manner by Maxwell to make it really a part of theory which it never was before. Maxwell pointed out its application to the possible or probable explanation of electric effects by the influence of a medium, and showed that that medium—the medium whose motions constitute light—must be ether. Maxwell's "electro-magnetic theory of light" marks a stage of enormous importance in electro-magnetic doctrine, and I cannot doubt but that in electro-magnetic practice we shall derive great benefit from a pursuing of the theoretical ideas suggested by such considerations. In fact, Heaviside's way of looking at the submarine cable problem is just one instance of how the highest mathematical power of working and of judging as to physical applications helps on the doctrine, and directs it into a practical channel.

(To be continued.)

THE HERMITE ELECTRO-CHEMICAL BLEACHING PROCESS.



THE HERMITE ELECTRIC BLEACHING APPARATUS.

The accompanying illustration represents the arrangement of the plant for the Hermite electrical bleaching process, lately installed at Messrs. Evans and Owen's Paper Works, near Cardiff. The plant is capable of producing equal bleaching effect to two tons of bleaching powder per twenty-four hours, and was constructed and installed by Messrs. Paterson and Cooper to the order of the Hermite British Electro-Bleaching Company. Briefly described, the Hermite process consists in manufacturing a solution of high bleaching

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power by electrolysing an aqueous solution of magnesium chloride. The salt is decomposed by the current at the same time as the water. The nascent chlorine, liberated from the magnesium chloride, and the nascent oxygen, liberated from the water, unite at the positive pole, and produce an unstable oxygen compound of chlorine of very high bleaching power. The hydrogen and the magnesium go to the negative pole; this last decomposes the water and forms magnesium oxide, whilst the hydrogen is disengaged. If in this liquid coloured vegetable fibre is introduced the oxygen compound acts on the colouring matter, oxydising it. Chlorine combines with the hydrogen to form hydrochloric acid, which, finding itself in the presence of magnesium in the liquid, combines with it and forms the initial chloride of magnesium. Thus a complete cycle of changes goes on so long as the electric current acts on the solution in the presence of colouring matter. The cycle is a perfect one, in which there are four elements—the electric current, chloride of magnesium, water, and the colouring matter. Only two of these elements are used up whilst bleaching—the electric current and the water. The magnesium chloride serves over and over again. There is only a simple displacement of molecules, and the chlorine acts as a vehicle to discharge the nascent oxygen on the colouring matter. Mr. Hermite, after prolonged research, has arrived at the conclusion that it is magnesium chloride which of all chlorides gives the only commercial and complete results.

The plant at Messrs. Evans and Owen's works consists of 20 "electrolysers" arranged in two rows, through which the solution of magnesium chloride is constantly circulated. Each electrolyser consists of a galvanised iron box open at the top and with a perforated pipe at the bottom. The box is filled with the electrodes, which consist of a series of platinum plates connected to the positive pole of the dynamo, and a series of circular zinc plates interspaced with the platinums and connected to the negative pole of the dynamo. The solution is admitted at the bottom through the perforated pipe, and overflows the sides of the box, passing in between the plates, and being decomposed, then falls into a cement tank underneath. From this bottom tank it is taken by means of a 12in. centrifugal pump into the tank above, and is ready to pass through the electrolyser again according to the strength required. The top tank is a large, egg-ended boiler, and is connected to each electrolyser by means of a rubber pipe and cock.

It is from the top tank that the solution is pumped over to the bleaching mill, a distance of some 50 yards, by means of an 8-inch centrifugal pump, where it is received in tanks, from which it is drawn as required. The method of working is very simple; the pulp ready to be bleached being in a "potcher," the electrolyser bleaching solution is run in, and the washing drum kept working; as the solution passes through the pulp its bleaching power is exhausted, and it is returned by means of a pipe to the top tank from which it originally started, and from whence it again passes through the electrolyser and is regenerated.

The amount of solution remaining in the pulp after bleaching is recovered by a system of displacement in drainers or by means of a press plate.

The current is supplied by three of Paterson and Cooper's Phœnix shunt-wound dynamos, each giving a current of 1,000 to 1,200 amperes, with a difference of potential at the terminals of 40 volts. The electrolysers are arranged in series, eight on each of two dynamos and four on the other, this has been so arranged that another four may be added when required. Each circuit has an ammeter and voltmeter connected. The dynamos are driven by a compound condensing engine of the tandem type, capable of indicating 300 horse-power, the amount actually taken up at present being 200 horse-power.

An important part of the plant is that for the preparation of the magnesia necessary for keeping the solution basic. It consists of a vertical tank fitted with a stirrer, in which lime milk is made. This is run from thence into a shoot, discharging into any one of three vertical tanks, each fitted with a stirrer. These tanks are all placed above the main tank supplying the electrolysers, so that by merely opening a cock the "base," when prepared, can be run down at will. The three vertical tanks are partly filled with a solution of magnesium chloride, and then filled to the top with the lime milk. The lime throws down the magnesia, the calcium chloride which remains is siphoned off, the magnesia being then washed twice is ready for use.

The cost of bleaching by this system compares very favourably with the old process.

The fibres bleached are not deteriorated in strength to anything like the same extent as with bleaching powder.

There are many modifications of the process for the bleaching of linen and cotton yarns, piece goods, &c., and also many different forms of apparatus, which are the subject of numerous patents in the names of Messrs. Hermite, Paterson and Cooper, in England and abroad.

The plant has been manufactured and erected by Messrs. Paterson and Cooper, under the personal superintendence of Mr. Hermite.

This process has been adopted on a large scale by several important paper makers, some of whom, after prolonged trial upon a limited scale, have given extensive orders.

BOOKS, &c., RECEIVED.

"Northern District Telephone Company Pocket Directory" (Sunderland).

D. G. Cresswell and Son's (Bradford) Price List.

"Bellhangers' Handbook." By F. B. Badt. (Chicago: Electrician Publishing Company.)

"The Insurance Year Book, 1889." (London: Simpkin, Marshall and Co.)

List of Subscribers for the Dundee District. The National Telephone Company. (Dundee.)

"The London Bridge Diary for 1889." (London: Chas. Straker and Sons.)

"Almanack-Annaine de l'Electricité et de l'Electro-chimie Année, 1889." France-Belgique-Suisse. (Paris: Firmin Leclerc.)

"Technology." Quarterly. (Boston: Massachusetts Institute Technology.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

MONDAY, January 21st.

Society of Arts.

8 p.m. Cantor Lecture II. 1. "Egyptian Tapestry." By Alan S. Cole.

TUESDAY, January 22nd.

Royal Institution.

3 p.m. Afternoon Lecture, "Before and After Darwin." By George John Romanes, M.A., F.R.S.

Society of Arts.

8 p.m. Applied Art Section. "Some Recent Movements in Relation to the Applied Arts." By Sir James D. Linton, P.R.I.

Institution of Civil Engineers.

8 p.m. Ordinary Meeting. Discussion on "The Compound Principle as Applied to Locomotives." By Edgar Worthington, B.Sc., A.M.I.C.E.

WEDNESDAY, January 23rd.

Society of Arts.

8 p.m. Ordinary Meeting. "Electric Meters for Central Stations." By Prof. George Forbes, F.R.S.E.

THURSDAY, January 24th.

Royal Institution.

3 p.m. Afternoon Lecture, "The Metamorphoses of Minerals." By Prof. J. W. Judd, F.R.S.

Institution of Electrical Engineers.

8 p.m. Ordinary Meeting. "The Insulation Resistance of Electric Light Installations." By Prof. Andrew Jamieson, Member.

FRIDAY, January 25th.

Institution of Civil Engineers.

7:30 p.m. Students' Meeting. Paper to be read, "Water Softening and Filtering Apparatus for Locomotive Purposes, at the Taff Vale Railway Company's Penarth Dock Station, near Cardiff." By W. W. F. Pullen, Stud. Inst. C.E.

Society of Arts.

8 p.m. Indian Section. "The Asiatic Colonisation of East Africa." By H. H. Johnston, F.R.G.S.

Royal Institution.

9 p.m. "Meteorites and the History of Stellar Systems." By Prof. G. H. Darwin, M.A., F.R.S.

SATURDAY, January 26th.

Royal Institution.

3 p.m. Afternoon Lecture, "The Character of the Great Composers and the Characteristics of their Works." By Prof. Ernest Pauer.

Physical Society.

3 p.m. Notes on "Polarised Light," on "The Structure of Natural Diffraction Gratings of Quartz," on "Ahrew's Modification of Delezenne's Polariser," and on "The Use of Two Quarter-Wave Plates," in Combination with a Stationary Polariser;" and a Note on "A Relation Between Magnetisation and Speed in the Dynamo-Machine." By Prof. S. P. Thompson, D.Sc.

"On the Divergence of Electromotive Forces from Thermo-Chemical Data." By Prof. E. F. Herrmann.

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
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„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
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Particulars relating to Advertisements will be promptly forwarded on application to this office.

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Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

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"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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THE DIRECTORY for 1889 will SHORTLY BE READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 295
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 300
Alkaline Accumulators and the "Gymnote" Submarine Torpedo Boat. By P. B. Elwell. Illustrated 302
The Institution of Electrical Engineers.—Sir Wm. Thomson's Presidential Address ... 303
The Hermite Electro-Chemical Bleaching Process. Illus..... 306
Meetings of Scientific Societies. 307
"Ether, Electricity and Ponderable Matter"..... 308
The Electric Lighting Concessions in Paris..... 310
Notes on the Design of Electric Motors. By Albion T. Snell. Illustrated..... 310
Reading the Barometer at a Distance. Illustrated..... 315
Legal Intelligence—
In re Gaulard and Gibbs' Patent.—Appeal. 315
American Notes 316
Correspondence—
The Institution of Electrical Engineers.—Shelford Bidwell, F.R.S, M.Inst.E.E. ... 318
Correspondence—*Continued.*
Mr. Edmunds' Method of Maintaining Constant Current. — Douglas C. Bate 319
Standards of Light.—M. Whitley Williams. 319
Bath Electric Lighting.—H. St. John Winkworth 319
The Albion Gas Engine.—G. T. P. 320
The Lighting of Kimberley. A Correction.—J.G.Statter and Co. (Limited)..... 320
Theatre Lighting.—S. Sudworth..... 320
Messrs. Woodhouse and Rawson's Catalogue of Contractors' Electrical Supplies 321
Patent Record 321
Companies' Meetings, &c.—
The Western Counties Telephone Company 322
The Direct United States Cable Company 322
Eastern Telegraph Company (Limited) 323
The Equitable Telephone Association (Limited) 323
New Companies Registered ... 323
City Notes, &c..... 323
Companies' Share List..... 324

SPECIAL NOTICE.

With the next number of "The Electrician" will be published a Steel Plate Portrait of Sir William Thomson, F.R.S., President of the Institution of Electrical Engineers.

"Electrician" Subscribers should receive this Plate Gratis. To non-subscribers the price of "The Electrician" for January 25th will be Sixpence.

Subscribers should promptly address complaints of non-receipt of the Portrait to The Publisher.

"ETHER, ELECTRICITY AND PONDERABLE MATTER."

Nothing is perhaps more remarkable in Sir William Thomson's career than the fact that whilst his attention has been so unremittingly bestowed upon those questions which are amongst the most difficult of any in the whole range of physical and mathematical science, yet he has nevertheless continued to maintain the closest touch with the practical everyday side of life; so that, for instance, his inventions are marked no less by minute and painstaking attention to detail than by the brilliancy and originality of their conception. It was in this spirit that on Thursday evening, before addressing himself to the subject proper of his discourse, he took occasion to insist upon the elementary fact that "electrical engineering is not confined to ether and electricity," but that the would-be electrician "must condescend to ponderable matter"—in other words, that first and foremost he must be a mechanical engineer, and something he must also know (if possible, a good deal) of mathematics, dynamics and chemistry. Doubtless this is a warning which cannot be too often repeated by the leaders of the profession, and it is especially valuable when thus delivered *ex cathedra*.

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But we venture, after all, to think that one of the most valuable lessons which the members of the Institution of Electrical Engineers will have derived from this Address may be summarised in the terms of a proposition almost the converse of the above. Electrical engineering, we have been forcibly reminded, is not confined to electricity and ponderable matter. There is also a mysterious something without which (however we may be content to ignore it in our everyday work) no single step can be taken towards the least understanding of the intimate nature of the processes with which the electrician is concerned. It is undoubtedly, on the one hand, a legitimate subject for gratification that the theory of applied electricity can be made to rest upon a practical basis in which we virtually neglect the ether, and think of electricity and of ponderable matter alone; but, on the other hand, it is surely a healthy and a desirable thing that our thoughts should now and again be directed towards that occult and mysterious medium of whose properties we may know a little, but whose mechanism and structure the acutest intellects fail as yet even to surmise, save incompletely. Scarcely need we stay to add that it is to Sir WILLIAM THOMSON himself that we owe the most far-reaching and the most successful attempts that have hitherto been made to grapple with the profound difficulties here presented. For forty-two years, as he told us, the attempt to solve these questions has been with him day and night, "not all of every day, nor all of every night, but there have been very few days and nights in which I have not been trying to find it; but I have not succeeded in finding it yet."

The beautiful gyrostatic experiments which were exhibited at the close of the Address will have done much to assist the non-mathematician to conceive the actual possibility of a mechanical explanation of magnetic phenomena. Combining the gyrostat with the "molecular skeleton" framework of constant area we are provided with something approaching a concrete illustration of a medium which is competent to perform very many, though not all, the operations required by electromagnetics. Yet electrostatic phenomena are still, as Sir WILLIAM expressed it, left out in the cold, and their inclusion is even at present unimaginable. It is his abiding conviction that in the ether "there must be some kind of structure . . its molecules must have some shape; they must have some kind of relation to one another," and undaunted by apparently irreconcilable demands, he still looks forward confidently to the ultimate and complete solution of the problem. We may be permitted to quote the concluding passage of the Address:—

"And there, then, I am afraid I must end by saying that the difficulties are so great in the way of forming anything like a comprehensive theory that we cannot even imagine a finger-post pointing to a way that can lead us towards the explanation. That is not putting it too strongly. I only say we cannot imagine it. But this time next year; this time ten years; this time 100 years, probably, it will be just as easy, perhaps, as we think it is to understand that glass of water, which seems now so plain and simple. I cannot doubt that these things, which seem to us so mysterious, will be no mysteries at all; that the scales will fall from our eyes; that we shall learn to look on things in a different way; when that which is now a difficulty will be the only common-sense and intelligible way of looking at the subject."

Now, it is scarcely necessary on our part to disclaim the intention of offering any criticism whatever upon Sir WILLIAM THOMSON'S views, as embodied in this memorable Address; still less shall we venture to assign any probable limit to the future extension of human knowledge. There is, nevertheless, one simple question which we may perhaps usefully raise, especially in the light of certain quite novel conclusions, to which we shall draw attention. So far as we have been able to gather from the whole of Sir WILLIAM'S treatment of the subject, he looks upon the ether as consisting, in some sense of the word, of matter. But we are not clear to what extent he regards the ether as being subject to the same dynamical laws as those which have been derived from our experience of ordinary matter. It must be remembered that these laws are based on experience, and we are unable to say that as we know them so they must inevitably have been. How, then, can we feel sure that they at all hold good for a medium upon which the law of gravitation asserts no claim? If, for instance, the ether be not matter at all, would the laws of motion as we know them necessarily hold good for it, or would it still be possible to hope for an intelligible exposition of the phenomena it presents? Many years ago Sir WILLIAM sought to obtain at least an inferior limit to the density of the ether in planetary space.* His method is based upon the measurements by POUILLET and HERSCHEL of the whole amount of solar radiation received upon a given surface in a given time, and upon an assumption with regard to the distortion of the ether in any wave which is considered to be small compared with the length of the wave. In the result he showed that the mass of the ether contained in a cubic mile of space near the earth must be *at least* $\frac{1}{1,000,000,000}$lb. And to show that this is not by any means a surprisingly small quantity, he calculated that at the distance of a few radii from the surface of the earth a cubic mile of air (if the atmosphere extends so far, which is for other reasons improbable) would be represented by a fraction of a pound, having 329 figures in the denominator! Remembering that this calculation assigned only the *inferior* limit of the density of the ether, it is instructive to compare the result with some figures recently obtained by M. HIRN, and which will be published in a forthcoming work of considerable importance, entitled "Constitution de l'Espace Céleste." M. HIRN attacks the problem by calculating, in the first instance, the density of a medium whose resistance would be capable of producing a secular acceleration of half-a-second per annum in the mean motion of the moon. He finds that this demands the presence of one kilogramme of matter disseminated in a space of 975,000 cubic kilometres, equal to one pound in 104,000 cubic miles; so that under this supposition the medium would have a density considerably greater than that assigned by Sir WILLIAM THOMSON for the inferior limit of the actual ether. In fact, M. HIRN'S medium has a density equal to about one millionth of the vacuum of a Crookes tube.

But what are the consequences of the presence of even so attenuated a medium when diffused in space through which a planet tears its way? Assuming a very high specific heat, he finds that, at the surface of the moon the ether would be raised by the shock of the collision to a temperature of no less than 38,000°C.! Moreover, in a passage which we do not quite follow, M. HIRN, if we understand him right, says that the surface of the moon itself would attain to a temperature of about 300,000° C. This calculation refers, of course, to the case of a planet which possesses no atmosphere, but the consequences would be equally serious for the Earth, since the atmosphere would soon be driven off altogether by the combined heating and shearing effects. If these calculations be capable of verification, and even when allowance is made for the greater density of the medium assumed by M. HIRN, it seems to us that the difficulty of imagining the ether to be in any intelligible sense a modification of ordinary matter is greatly intensified.†

* "Mathematical and Physical Papers," Vol. II., p. 30.

† It is necessary, however, to remark that both Adams and La Place came to the conclusion that ether resistance if present would have no sensible effect upon the mean movement of the nodes or of the lunar perigee.

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Dr. YOUNG* long ago wrote that "the luminiferous ether, pervading all space and penetrating almost all substances, is not only highly elastic, but absolutely solid!!!" And the learned doctor's trebly pointed exclamation does not too much emphasise the incredible character of the statement. HERSCHEL† calculated the force which may be supposed, according to the undulatory theory of light, to be constantly exerted at each point in space, and finds it to be 1,148,000,000,000 times "the elastic force of ordinary matter at the earth's surface"; so that the pressure of ether per square inch (under, or rather within, which we live and move and have our being) must be about seventeen billions of pounds. But as Sir WILLIAM THOMSON pointed out in the Baltimore lectures, these difficulties tend to diminish in face of the fact that properties at first sight almost equally paradoxical may be observed in ordinary matter. The supposition that the ether acts like a perfectly elastic solid for vibrations executed in periods of from the 100 to the 1,600 billionth of a second, and is yet highly mobile to bodies having a velocity of, say, 20 miles a second, is less difficult of comprehension in view of the fact that a tuning fork may be made of Burgundy pitch—a substance which, therefore, behaves as an elastic solid for vibrations with periods of a small fraction of a second. Yet a bullet will by its own weight penetrate into it several inches in the course of a few months.

The bewildered student will be inclined to say, "for this relief much thanks;" but even now it is refreshing to recollect that we have still Ohm's law and the Parallelogram of Forces, and that the advantage (in certain cases) of a closed magnetic circuit remains wholly unimpaired.

THE ELECTRIC LIGHTING CONCESSIONS IN PARIS.

The following is a list of the streets marking the boundaries of the districts in which concessions have been granted by the Paris Conseil Municipal to electric lighting companies:—

Gaston Cenisier District.—Avenue de la Grande-Armée, Avenue des Champs-Elysées, Rues de Rivoli, du Louvre, Montmartre, du Faubourg-Montmartre, de Châteaudun, de Londres, de Constantinople, de Rome, Cardinet and de Tocqueville.

The Société Anonyme du Secteur de la Place Clichy District.—Boulevard Pereire, Rue de Rome, Boulevard Haussmann, Rues du Havre and d'Amsterdam, and the Avenus de Clichy and Saint-Ouen, up to the fortifications.

Victor Popp Company's District.—Rue de Belleville, Faubourg du Temple, Place de la République, the Grands Boulevards, Rues Royale and de Rivoli, Place de la Concorde, and the Quais on the right bank up to the fortifications.

The Surrey-Montant Company's District.—Boulevards Ornano and Barbès, Faubourg Poissonnière, Rues Poissonnière, des Petits-Carreaux, Montorgueil, Baltard and du Pont-Neuf, Quais des Orfèvres and du Pont-Neuf, Rue de la Cité, Parvis Notre-Dame, Pont d'Arcole, Rue du Temple, Place de la République, Faubourg du Temple, Rue de l'Entrepôt, de Lancry, des Récollets, Faubourg Saint-Martin and Rue de Flandre.

The Edison Continental Company's District.—Avenues de Saint-Ouen and de Clichy, Rues de Clichy and de la Chaussée-d'Antin, the Grands Boulevards up to the Rue Richelieu, the Place de la Bourse, the Rues Joquelet, Montmartre, Grands Boulevards up to the Rue du Faubourg-Saint-Denis, the beginning of the Rue du Faubourg-Saint-Denis, the Faubourg Poissonnière up to the Rue d'Enghien, the Rue Bergère, the Rue du Faubourg-Montmartre, Rue Grange-Batelière, Rue Geoffroy-Marie, Rue Richer, Cité Trévise, Rue Bleue, Rue Lafayette, Place Cadet, Rue Rochechouart, Rues Clignancourt, Ordener and du Mont-Cenis.

The Marcel-Deprez Company's District.—The Boulevards Ornano and Barbés, the Boulevard de Magenta, Place de Roubaix, Rue de Dunkerque, the Boulevard Denain, Rue du Faubourg-Saint-Denis, Rue d'Aboukir, Rue du Caire, the Boulevard de Sébastopol, the Boulevard Saint-Martin, Place de la République, Rue de la Douane, the Quai de Valmy, and the Rue d'Allemagne.

When the question of these concessions first came before it, the Conseil Municipal decided that the districts conceded to the companies should form a series of segments, proceeding from the centre of Paris to the fortifications, and stipulated that within four years the *concessionnaires* should be ready to provide light in any and every part of their district. This naturally gave rise to strenuous opposition on the part of the companies. After prolonged consideration of the matter, concessions were finally granted under a security of 300,000fr. in each case, except that of the Clichy Company, whose district is smaller, and which only has to deposit 100,000fr., and upon the condition that cables are laid in all the large streets within two years, and within four years in every street where ten lamps are asked for per every ten metres. These districts, it may be remarked, overlap in several parts, and the companies can, therefore, compete in these "quartiers." The concessions also only refer to private lighting, the companies merely holding the right of laying mains in certain streets, with a view of furnishing the householders with the current. As to public lighting, that will become the object of conventions between the companies and the authorities. It is expected that work will now be actively pushed forward by the various *concessionnaires* in the districts allotted to them.

The municipal central station at the Halles Centrales still forms the subject of lengthy discussions. The last question which has arisen is that of the nationality of the dynamos. Since the days when it issued the famous *cahier des charges* relating to the distribution of electricity, the Conseil Municipal has posed as the protector of French industry. Quite recently, after having voted the concessions mentioned above, the Conseil, in order that there might be no fear of misunderstanding, passed a resolution to the effect that in Article 27 of the *cahier des charges* the word "apparatus" included wires and lamps as well as engines and dynamos, all of which will now have to be of French manufacture in the case of the *concessionnaires*. This being so, great astonishment was caused by the Conseil Municipal accepting the tender of M. Patin, agent in France for M. Ferranti, of London, since it appeared that the Conseil had no intention of imposing upon itself, in the case of the station at the Halles Centrales, the stringent conditions it sought to impose on the *concessionnaires*. On December 31st MM. Dumay and Paulard called attention to this anomaly, and the committee which had been charged with awarding the contracts immediately protested and gave as an excuse the superiority of the Ferranti machines. The only two electricians on the committee were M. Mascart and M. Potier. M. Mascart's opinion was as follows:—"If I had to start a central station myself I should give my preference to the Ferranti machine. But as a representative of the city of Paris, and looking at the matter from this point of view, I hold that the superiority of the Ferranti machine is not so great as to oblige the city of Paris to have recourse to foreign industry." M. Potier explained himself at considerable length. The choice, he said, lay between the Edison and Ferranti tenders; the latter was 40,000fr. dearer, but yielded 12 per cent. more. Each Zipernowski machine would give 68,400 watts at the terminals, each Ferranti 75,600 watts. M. Patin's machines, it is true, were 113,000 watt dynamos, and the engines arranged for were only equal to 90,000 watts, but M. Patin gave a guarantee in writing that his machines would have an 88 per cent. efficiency, even if provided with only 140 horse-power engines. Such being the case M. Potier said that he considered the Ferranti tender the best. The Conseil finally decided as follows:—"All the material for the municipal central station will be purchased exclusively from French firms, the efficiency being the same. The Conseil Municipal will be the judge, after a report from a technical committee nominated by the Conseil."

It will thus be seen that the affair remains in a somewhat confused and uncertain condition.

NOTES ON THE DESIGN OF ELECTRIC MOTORS.*

BY ALBION T. SNELL.

In discussing the design of electric motors it will be necessary to first of all consider the relation between the dynamo and the motor. The dynamo may be defined as a machine which converts mechanical work into electrical energy. The motor, when supplied with electrical energy, gives out mechanical work. So far, one is the converse of the other, and the dynamo is said to be a *reversible* machine.

The extent to which this is true depends very largely on the size of the machine under consideration. This follows from the fact that no matter how bad the design of motor, how weak the field, or how small the magnets or armature, it is sure to *run*. But a badly designed dynamo—one with relatively weak field-magnets say—will

* Young's *Works*, Vol. I., p. 415.

† Familiar Lectures on Scientific Subjects, p. 282.

* Paper read at the City and Guilds of London Institute Old Students' Association, on Wednesday, January 16th, 1889.

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often not excite at all. Or again, the proportions of armature and field may be relatively correct, but the mass so little that the like result obtains. Why is this, if the dynamo be a reversible machine It has been shown that the reactions in the dynamo armature are not the same as those in the motor. And it is now generally admitted that the effect of self-induction in the dynamo armature is to increase the lead, while in the motor it tends to diminish it. And Mr. Mordey has pointed out that in the generator the effects of self-induction in the armature windings are opposite to those of the Foucault currents in the core ; but in the motor they tend to increase each other.

The writer has had these differences brought under his notice very forcibly in the course of his experience, having been connected directly or indirectly with the design of more than 400 machines, varying in output from ·1 horse-power to 100 horse-power, and from 20 watts to 70,000 watts.

The chief cause of this difference between dynamo and motor is to be found in the mutual effects of armature and field. Profs. Ayrton and Perry so far back as 1883 showed, both mathematically and practically, that in the motor the magnetism of the armature and that of the field *might* be added ; in fact, the motor-effort is proportional to the magnetic strength of both armature and field-magnets, while in the dynamo the field due to the armature, considered as an independent magnet, must necessarily subtract from that of the magnets. These main distinctions occur in the nature of things. Their magnitude at first seems to be considerable ; but really the effect depends very largely on the actual dimensions and the relative proportions adopted.

An ideal dynamo has an armature with neither internal resistance nor magnetism *per se*. The field-magnets alone are the source of lines of force. This condition may be the more nearly attained as the size and weight of the machine be increased. All text-books tell us that the field-magnet should be as powerful as possible, and the armature relatively weak. The exponents of the "reversible theory" and its corollary, "the better the dynamo the better the motor," appear to have had more experience of large machines than small ones. And their *experimentum crucis* necessarily leads them to such views. When such authorities as Hopkinson and Silvanus Thompson, Kapp and Mordey, assert anything electrical, few venture to disagree. But I beg to submit that an extended experience with small and medium size machines would modify their views, especially if weight-efficiency be an object in the design.

Be this as it may, a motor weighing 70lb. can be made to give one B.H.P. with 70 per cent. efficiency of conversion ; but the same machine run as a dynamo would require nearly 50 per cent. more speed to give an output of 746 watts, and even then the efficiency between output and belt power would be nowhere near 70 per cent. If this be true, and I think it beyond dispute, the theory and corollary require some modification. The approximation to the same efficiency when used as a dynamo or motor becomes the more apparent as the size of the machine is increased ; but even up to 50 H.P. I prefer to make certain structural differences in the design of dynamos and motors, particularly if they be series-wound. With shunt-machines the difference seems to be less marked owing to the field being nearly constant. If I mistake not, both Hopkinson and Mordey have founded their opinions on observations made from large shunt-machines.

Much more might be said on this branch of the subject, and numerous actual experiments might be given in support of my views, but this would digress too much from the object of this Paper. With these introductory remarks on the character of motors and their relationship to dynamos, I will pass on to the general design of motors.

There are two broad lines on which motors can be designed. They depend entirely whether weight and overall dimensions enter into the problem. It is only necessary to admit that a powerful armature with many ampere-turns and a relatively weak field will give the same torque as a strong field and a weak armature. Granting this, we can design a motor to give a certain torque independently of the total weight to some very considerable extent. We shall be guided in the proportion of armature and field by the work expected of the motor, by the price allowed for production, by the intended cost of future maintenance, and by the desired life. These two methods of design depend on the point of starting. In the *first* we take an armature of given size, select a certain surface velocity, and build the field as small as possible to give the desired torque. In the *second*, a certain type of field iron being determined on, we select an armature of sufficient cross-section to give the required results. The first of these two methods is by far the more scientific, inasmuch as the dimensions of the most costly part of the motor can be made a minimum. The second method, however, will sometimes occur in practice, and it is well to note the possible results of this as well as those of the more general case.

When designing a motor to do particular work the following points should be considered :—

(1). What is likely to be the average torque on the motor and driven shaft ?

(2). Is the motor to run continuously or only for short periods at more or less frequent intervals ?

(3). What variations of load may be expected ? and

(4). What will be the maximum torque on the motor shaft ?

(1 and 4) will determine the characteristic of the motor and the particular part of the curve at which the average torque shall be arranged to fall.

(4) will determine the size of the shaft and strength of the bearings.

(1) gives us the ratio of the speeds between the motor and the driven shaft.

(2 and 3) determine the limiting safe rise of temperature,

While the winding must be designed to satisfy all the conditions as nearly as may be.

It is not possible within the limit of a short Paper to thoroughly analyse the different points to be observed. The general method can alone be indicated, and experience must teach the engineering student the rest. I will roughly run through the several conditions of design, and give such hints as appear likely to be of use.

The first thing to be noted is the torque on the driven shaft. This is not always an easy thing to get at owing to the want of a little scientific nous in the ordinary mechanic. If, however, this be known it is possible to determine within a few per cent. the required current, and the best ratio of gearing to get a maximum average efficiency from the motor. If this be accomplished the motor will be a success. If the motor be designed on the assumption of so much horse-power being required, and gearing be accordingly selected, it probably will happen that, though the estimate of power be fairly correct, the motor will be unsuited to the work. The current, and consequently the torque on the motor-shaft, will probably be excessive. The efficiency of the motor will thus be low, and the electrical horse-power absorbed too great, while, further, the speed will be too slow. The obvious remedy would be an increase in the ratio of the intermediate gearing. But if the surface velocity of the motor be correctly designed the increased speed will be too great, and, consequently, introduce other difficulties ; in fact, the motor will be a failure—not from any intrinsic fault, but simply because improperly designed for the work.

Daily one comes across machines driven by electricity, steam, air or water, in which the same fault appears. The speed of the prime shaft is not properly proportioned to that of the main or driven shaft. The consequent loss in possible efficiency is oftentimes not known, or if suspected, is ignored. This sort of thing did well enough years ago ; but addressing a body of educated men who are likely to occupy leading positions among the engineers of the immediate future, I cannot pass it by without protest. I therefore beg to impress on you the necessity of determining in some way or other the actual number of ft. lb. required to make one revolution of the main shaft. Your ingenuity will suggest many ways of doing this in most cases.

As an illustration of my point, I will mention the many attempts to run electric tramcars by direct gearing, *i.e.*, without a counter-shaft. Nearly every firm that has tried the tramcar problem has made the attempt. The last has been the Sprague motor line at Richmond, United States. That the method is unsatisfactory and can be much improved on there is no doubt, for Mr. Sprague has already (October 2nd), 1888, published drawings of a new tramcar involving two motors with *countershafts*.

Engineers using electric motors seem to forget that, although very efficient at or about a certain speed, they are most inefficient at low speeds (*vide* curves on next page).* Too much stress is laid on th property of a motor exerting maximum torque at starting. It is forgotton that the efficiency is *nil* under the condition of maximum torque, and that it increases very slowly until the point of 50 per cent. is reached. There are other sides, of course, to the question ; but I wish here to strongly emphasise the primary condition of motor design, viz., attention to the torque of motor and main shaft.

Having, then, determined the torques of the system the ratio of our gearing is known. Let us suppose that the motor torque be $\frac{1}{10}$th that of the main shaft, and that the gearing be accordingly in the ratio of 1 : 10. We have now to select an armature that will give us this torque at the speed required, satisfying also the conditions of durability, and that the rise of temperature will not exceed a certain limit, say 60° F., above the temperature of the room.

The mathematical expression for the torque of a motor is simple.

Let T be the torque. The output required of the motor at n revolutions per minute is, say, 1 B.H.P.

* Curve E E is the values of the E.H.P. for the different speeds, the motor running at constant potential. O c is an approximation to the corresponding B.H.P.; and O F F is the commercial efficiency (plotted to another scale). It will be noted that the efficiency increases at first with the speed, and, after attaining a maximum, slowly decreases, having passed through two points of 50 per cent. efficiency.

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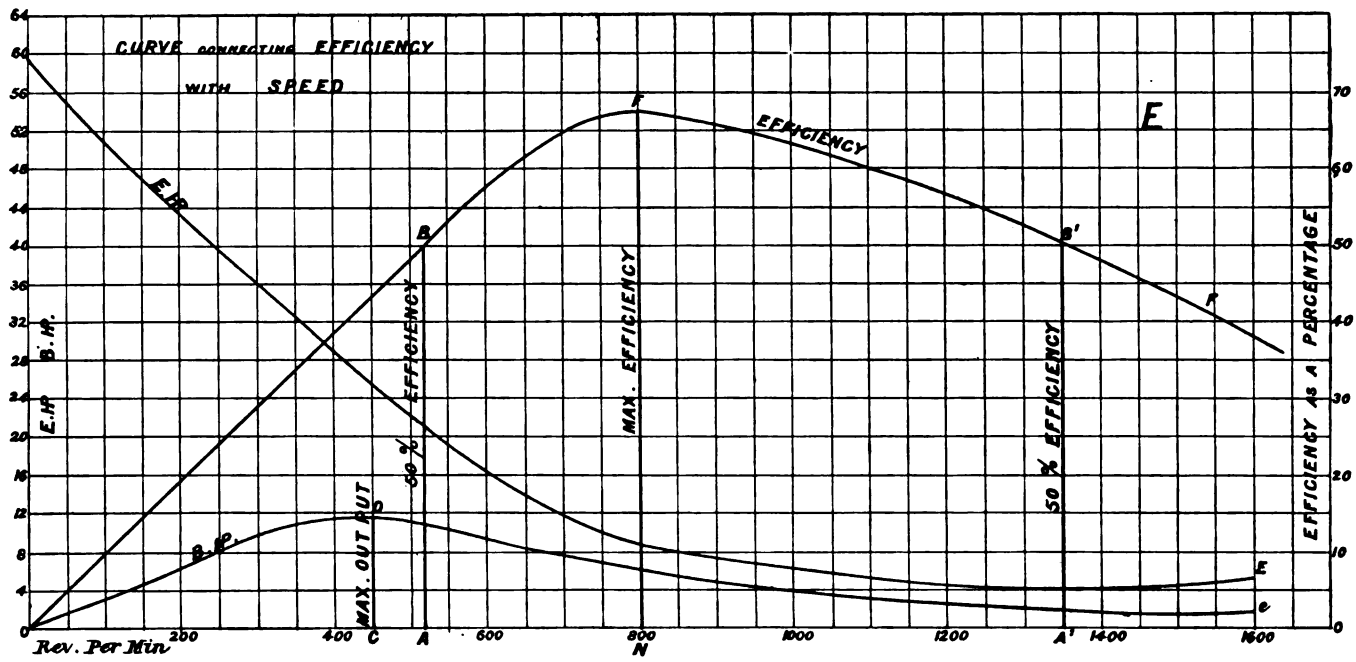

CONSTANT E.M.F. 400 VOLTS.

Then, $$T = \frac{B.H.P.}{2\pi n} = \frac{33{,}000}{2\pi n} = \frac{5{,}280}{n} \text{lb. ft. } (\alpha).$$

That is, the moment of the forces tending to turn the armature is equal to $\frac{5280}{n}$ lbs. acting at a radius of 1ft.

To get the exact pull on the periphery, it will be necessary to multiply this quantity by the ratio $\frac{1}{r}$, where r = the mean radius of the armature in feet.

The tangential strain on the wire is therefore

$$= \frac{5280}{n} \cdot \frac{1}{r} \text{lbs. } (\beta).$$

This latter quantity is what we require in designing the motor. In order to obtain the desired torque on our armature, we make $T = \frac{Z_a N t C_a}{2\pi}$ (γ), where Z_a = the number of lines of force passing through the armature, $N t$ = the number of turns of wire counted all round, and C_a = current flowing in the armature. It will be noted that the field does not come directly into the question. The function of the field-magnets is only to supply a magnetic field. It will be our care to so arrange the magnets and their windings that the proper value of Z_a is obtained. This is all that is necessary now. I shall have occasion to comment on this assumption later on when considering the field.

We have now to determine the values of Z_a, $N t$ and C_a.

C_a will usually be given us by the condition of supply and the horse-power required.

Z_a can be determined from the equation $Z_a = 2 a b z$ (δ), where z = desired number of lines per square inch, a = depth of core in inches, b = the length of armature *less the insulation* in inches.

Experience alone can tell us the best shape and size of armature core, but since the total cross-section $(=2 a b)$ is known no great difficulty presents itself. The depth of core will be mainly determined by the style of winding and the value of T. For a small torque a small armature and a large number of revolutions will be chosen; for a large torque a large, slow-speed armature is required. It will be necessary to note that a large cylinder or ring armature of short length is equivalent to a long drum of smaller diameter.

Then, assuming that the core be chosen, a and b are known. It only remains to substitute these values in (γ) and solve for $N t$. If the quantities are properly chosen $N t$ will have such a value that for a suitable current density the depth of winding will be about 10 per cent. of the core radius for cylinders and 15 per cent. for drums.

If the value of $N t$ be not a rational one the dimensions of the core must be altered. A few trials will illustrate this important part of the design, but practice alone can give ease and certainty.

In actual practice the matter is much simplified by previous experience and by fixed sizes of cores. It is then customary to select a wire to suit the current given, and to vary the speed so as to make the magnetic density suitable for the work. This is the crucial part of the whole thing. In other words, the motor is designed to give the required torque at a certain part of the characteristic. This point varies with the shape of the curve and with the conditions of work expected. My meaning will be more easily seen when the field-magnets have been discussed.

The best relative dimensions of armature and field cores is an open question. This is apparent from what has already been said. It depends entirely on the object aimed at. If weight efficiency be the desideratum, the armature *must* be relatively powerful, and the cross section of the cores may be made equal, allowing, of course, for the different permeabilities of the iron used. But if cheapness be the principal object, then a heavy field and a small armature are necessary. Speaking generally, the field strength has to be *relatively* greater as the size of the machine is increased.

The design of the motor field presents some considerable difficulty to the student. There are so many shapes and forms in vogue, and the same end seems to be attained with such opposite forms. With few exceptions, too, even old-established firms are continually changing their patterns, often with no apparent effect other than a weakening of the public confidence, and a considerable needless expense. Indeed, the engineering draughtsman seems to be at his wit's end to bring out a new design. Yet there is really no ambiguity on the subject. Text-books tell us the best form of magnet is that, *cæteris paribus*, which offers the least magnetic resistance, with a maximum cross-section and a minimum perimeter. Theory then points to a horseshoe magnet, of circular form and round cross-section. Difficulties of construction, however, render this ideal form too costly, and the matter has to be compromised. It is to this endeavour to balance the advantages of theoretical indication with the necessities of engineering that we owe the numerous types of fields.

The design of the field is, however, not so important with the motor as with the dynamo, and a little consideration will enable the student to determine suitable proportions.

In the first place the field has to supply a certain number of lines of force to the armature, or is expected to form poles of such strength that, in conjunction with those found in the armature, the necessary torque will be obtained. If gross weight be neglected, and a minimum expenditure of copper be desired, the single horseshoe is chosen. Such machines are common enough, and may be made vertical, horizontal, or inverted. The two first types are the better, since the leakage is less. If a light-weight machine be required, even at the expense of copper, then double horseshoe magnets are used. This type involves twice the number of ampere turns to give the same strength of pole as the single magnet does; but yet it has considerable advantages. The resultant magnetic field is likely to be more uniform, and less trouble is given by the brushes as a rule. If the armature be of a large diameter—say more than 24in.—it is better to have a four-pole machine, although the ampere turns will be double that required with a double magnet, and four times that with a single one, if the same value of Z_a be taken. The Oerlikon dynamos, for the reduction of refractory ores, are made with six poles, and no doubt a more even distribution of magnetism is gained.

Having selected the form of magnet the question of length and cross-section of limb arises. Here the criterion is simply sufficient

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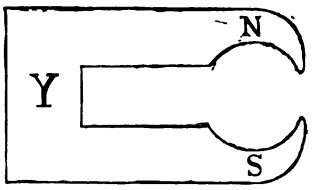
space to wind the wire necessary to give the desired strength of poles and area enough to carry the magnetic flux required.

Here the student finds the first real difficulty. Let us review the position. We know the E.M.F. of supply or the allowed number of volts; the current is also approximately known from the B.H.P. and the assumed efficiency of conversion. The torque of the motor has been determined and expressed in terms of the magnetic flux through the armature iron, the effective cross-section, and the number of turns of wire; the dimensions and shape of the core are also agreed upon. So far it is a physical certainty. The problem now, primarily, is to design a field-magnet which, in conjunction with the armature, will give the required number of lines in the armature core. This is strictly all that is necessary. The question of economy of material and labour spent in the building of the field-magnets cannot be discussed here.



The magnetic flux in the magnets, to give a particular value of Z_a, I believe to be unattainable by direct calculation. Let Z_1 be the total lines induced at S in a single horseshoe magnet, and assume the lines to pass through the yoke Y and enter the armature at N. The leakage which occurs all along the windings, and on the neutral part or yoke, reduces the value of Z_1 to, say, Z_2. But Z_2 is still further lessened by leakage of lines from N to S outside of the iron or copper of the armature, and the effective number of lines is reduced to, say, Z_3. Now, the ratio of $Z_1 : Z_2 : Z_3$ will vary according to the shape of iron, the length of cores, the contour of the winding, and the average density of magnetism. The problem is already sufficiently complex, but yet this is not all. We have yet to take into account the useful number of lines induced in the armature by its own windings = say, Z_4. This quantity is usually ignored in text-books, but I know from a large number of experiments that, if we wish to be accurate in our treatment of the subject, this factor must not be neglected. I cannot go into figures, but the importance of the motor-armature, considered as an independent source of magnetism, may be understood from the following considerations:—

Take a large series machine designed as a dynamo, having a relatively powerful field and weak armature. Let this be run at such a speed and output that the top of the straight part of the characteristic is just reached. Observe the speed, current, and terminal E.M.F. Then drive it as a motor, using the same number of volts on the terminals, and load the brake till the same value of the current is attained. The speed will usually, I think, be found to be nearly as great as that required as a dynamo.

Next take a smaller machine, designed as a motor—*i.e.*, one with a relatively weak field, &c., and repeat the experiment. It will probably be found that for the same values of current and terminal E.M.F. the motor speed will be considerably *lower*.

This variation in the two speeds is due partly to the lead required in different machines when run as dynamos or motors, and also largely to the relative importance of the armature magnetism. Two simple equations will assist the study of the problem. Neglecting friction, let

E_d be the internal E.M.F. of the dynamo.

$E_m = \frac{\text{B.H.P.}\ 746}{C}$ be the internal E.M.F. of the motor.

E_T be the terminal E.M.F. both of dynamo and motor.

C R be the volts lost over the internal resistance of the machine.

L_d be the value of the reactions of the dynamo armature.

L_m be the value of the reactions of the motor armature.

It will be necessary to note that L_d and L_m will vary with the lead required.

For the dynamo we have—

$$E_d = E_T + (C R + L_d) \quad . \quad . \quad . \quad . \quad . \quad (I.)$$

For the motor we have—

$$\frac{\text{B.H.P.}\ 746}{C} = E_m = E_T - (C R + L_m) \quad . \quad . \quad . \quad . \quad (II.)$$

Now, the speed of the motor varies as E_m, and the speed of the dynamo varies as E_d. It follows, then, that the motor speed should be *less* than the dynamo by a quantity proportional to $(C R + L_d) + (C R + L_m) = 2 C R + L_d + L_m$. If the speed of the motor be *greater* than that given by these equations, L_m, the only quantity that can possibly be varied, must be a factor of importance, and, moreover, of *negative sign*. This means that, in the motor, the armature adds magnetism to the resultant field, and thus increases the value of E_m, and consequently raises the speed. In the limit $L_m = C R$ and $E_T = E_m$—*see* (II). Even if these values were possible in practice, E_m would be still less than E_d; so that the relative values of the speeds can only be seen by examination of the ratios $\frac{E_m}{n_m}$ and $\frac{E_d}{n_d}$. It will be found with all normal machines that $\frac{E_m}{n_m}$ is less than $\frac{E_d}{n_d}$. One must not confound the question of efficiency with these experiments. The efficiency of a dymamo for a given E.M.F. and current varies *inversely* as the speed, for the torque is clearly proportional to some function of the current, and is nearly independent of speed. The motor efficiency for the same electrical constants varies *directly* as the speed. In fact, we endeavour to make the dynamo speed a minimum and the motor a maximum.

In the first experiment, say in a large Edison-Hopkinson dynamo, the efficiency either as dynamo or motor will not differ much, but I should expect the motor to give the better result by a small percentage. The influence of the armature is relatively small, and the lead very little. The only objection to the machine considered as a motor is the weight, and consequently, increased cost of material for a given output.

In the second experiment the armature is large compared with the field. Hence, the lead as a dynamo will be great—probably 30 degrees at least in a positive direction; as a motor the lead, if any at all, will be much less, perhaps 5 degrees in the negative direction. The machine will be inefficient as a dynamo, and require a high speed; but as a motor it will be *much more* efficient, though the speed will not be so great as that required for the dynamo. The second machine will be a good motor, efficient, light, and cheap.

This explanation is very rough, but it will help to explain the reason for considering the armature as an independent magnet in motor design. The Oerlikon plant, described in the technical press some six months ago, illustrates the point. The dynamo and motor have armatures identical both as regards the mass and distribution of iron and copper; but the motor field has 7 per cent. less copper and iron than the dynamo, and I know of many installations where proportionately much smaller motor fields are used with advantage.

Many attempts have been made to predetermine the characteristics of dynamos and motors; yet the best seem to be but approximations. From what has already been said it follows that the difficulty only lies with the number of lines of force in the field. This quantity is indeterminate, chiefly because we have no magnetic insulator. We can get the characteristic of the iron of both field and armature, and we know the resistance of the air-space. But we do not know and cannot as yet predetermine by calculation the loss of magnetism which will take place over a new type of machine. Mr. Kapp has shown that this leakage is a function of linear dimensions of the machine, and hence varies with every type; indeed, no matter how small the alteration in design the value of the lost magnetism is changed. Practically this presents no difficulty, as only a few types obtain with most firms, and a few simple experiments will determine the number of ampere turns to give any desired result.

The Brothers Hopkinson and Mr. Kapp were, perhaps, the first to move in this direction of calculating the ampere turns required in the field to give a definite magnetic flux in the armature. Both methods are well known, but a brief reference will assist us to follow the subject. Mr. Kapp started from a geometrical treatment of the design, and assumed the magnetic resistance of iron to be expressed by a law similar to that of Ohm, and the saturation effect was assumed to follow a tangent function. I have used the Kapp formulæ for many machines, both dynamos and motors; indeed, I think I was probably the first to apply them to motors; but the results are not satisfactory, particularly with large machines. The equations do not take into consideration the leakage in a sufficiently accurate manner, and the ampere turns have to be increased from 25 per cent. to 100 per cent. above the value given by calculation. The characteristic thus obtained usually rises too slowly, and after cutting the real curve about the point of half-saturation of the field-magnet, does not fall sufficiently rapidly. My experience, I believe, is fairly well borne out by other users of the Kapp formulæ.

Hopkinson starts on a different basis. He determines experimentally the curves of saturation of both field and armature iron, and expresses the magnetic flux in terms of absolute magnetising force $\left(\frac{4\pi S i}{10}\right)$ turns per centimetre length of core. The specific resistance of air is also determined by experiment. So far this is perfectly safe ground. But the characteristic of the machine itself is the summation of the curves of the field and armature iron and the air space, modified by the leakage and the reactions of the armature. Hopkinson has now to resort to experiment to find the magnitude of these disturbing influences, and a good deal of approximation or experimenting

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is required ; indeed, the method is not applicable to a new type of machine without considerable knowledge of the subject.

Prof. Silvanus Thompson, in the third edition of "Dynamo-Electric Machinery," gives a method combining both Hopkinson's curves and Frölich's equation :—

$$N = N_1 \frac{S\,i}{S\,i + (S\,i)_1}.$$

N = maximum number of lines in field-magnet.
N_1 = lines in field-magnets to give the diacritical value.
$S\,i$ = ampere turns to give N.
$S\,i_1$ = ampere turns to give N_1.

But this, again, demands an experimental determination of the leakage coefficient, and does not seem to me to advance the subject much.

Mr. Esson employs a modification of Dr. Hopkinson's method. Using the saturation curves of the iron and specific resistance of the air as his starting points, and selecting a definite value of Z_a, he determines the number of ampere turns per centimetre of magnet core to give this value in the armature, neglecting leakage or self-induction. With a known type of machine this method presents great advantages, for the field-winding is given by simple reference to the curves.

Fortunately for us practical men there is no pressing need of an exact mathematical solution. With a known type of field, machines of any output can be designed with certainty from previous experience, and easy applications of the rule of three.

It may be noted that the slope of the characteristic is mainly determined by the resistance of the air gap. The curves of the field and armature iron do not largely affect the general shape till the diacritical points of either be reached. If the field be so crowded with wire that this point be passed, then the characteristic of the machine will bend rapidly.

Before leaving this part of the subject, I will briefly examine the question of pole-pieces.

Judging from the variety of shapes of polar extensions obtaining in machines in the market to-day there seems to be no little ambiguity on the subject. Some makers use long poles, extending over nearly 160 degrees of the armature periphery. Others cover 90 degrees to 100 degrees. Some machines are to be found with long, thin, sharp extensions, whilst some have short, thick, and rounded ends. Each in its way accomplishes a particular end, but only want of knowledge could lead to the extreme proportions sometimes met with. This variety of dimensions in the pole-pieces and extensions arises from an attempted compromise between theory and simplicity of design.

Theory, on the one hand, points to an extended pole-piece if a low magnetic resistance of the air gap be desired. But since there is a tendency for the magnetic density to increase at the extremities of the poles, an undue lengthening of the arc encircled leads to a distortion of the main field. And, further, the position of commutation becomes a line, whilst really there should be some two or three segments on either side on which the brushes may rest without causing sparking or heating of the coils short-circuited beneath them.

Theoretical considerations, then, compel us to shorten the polar extensions, although we thereby raise the total magnetic resistance. This involves, however, no practical loss, for magnetism is cheap, and a few more ampere turns will compensate for the weakened field.

It is curious to note how the tendency to shorten the pole-pieces has increased during the last twelve months or so. The Manchester dynamo used to have pole-pieces extending over 139 degrees. I heard the other day of a Manchester machine with poles not more than 90 degrees in length. Messrs. Paterson and Cooper are also making both dynamos and motors with short poles ; so are many other firms.

In some designs there are practical reasons for shortening the poles. If the cores are vertical, it is a convenience to be able to slip the windings over the coils. To attain this the cores are prolonged and the poles bored out of them, instead of being built up of separate castings. This is applicable to both cast and wrought iron magnets.

Rounded polar extensions are also used in some designs, particularly with high-tension machines. I think this was first done in the Weston dynamos. Speaking generally, for motor pole-pieces I would recommend that the arc embraced be not more than 120 degrees, preferably rather less, and that the poles be rounded at all their extremities. The section of the poles should vary about in proportion to the magnetic flux desired. By a careful attention to this point the field may be properly spread over the whole of the coils beneath the poles, and the E.M.F. induced per coil be approximately the same. This is a matter of no little importance in large machines.

The best way of testing the activity of the different coils is the one first used by Mordey, I believe. By a simple arrangement of two movable brushes, the E.M.F. of coils in different parts of the field is successively measured and the result plotted. This gives the differential curve of potential. From this the integral curve may be obtained, or a direct experiment will give the same result. Fix one lead of the voltmeter to, say, the negative brush, and move the other in contact with the commutator through spaces equal to the angular width of one coil, taking readings at each space. These two curves show at a glance the relative activity of the coils and the distribution of the main field. No better method can be devised for showing the exact action of the armature, and the relative advantages of differently shaped poles and polar extensions are at once apparent.

This method is also very useful for showing the difference between the distribution of magnetism in the dynamo and motor field. I have derived considerable assistance from an exhaustive treatment of different machines in this manner. The results obtained are very curious, and serve to explain why it is advisable to make a difference between machines used as dynamos or as motors.

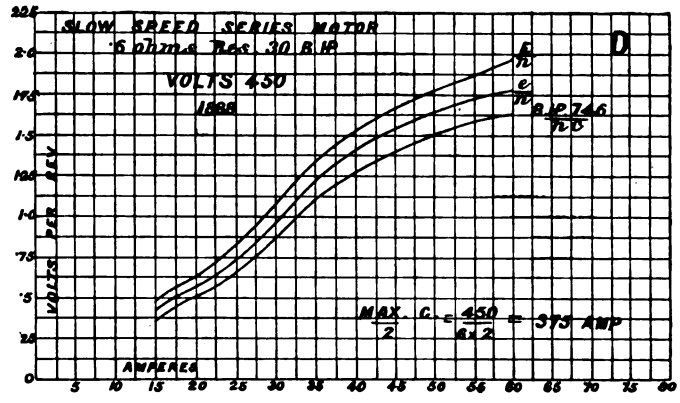
Generally motors are likely to have greater and more sudden variations of load than dynamos, hence the necessity for extra care in designing the pole-pieces. The principal point to be aimed at is to make the position of commutation sufficiently large for the variations likely to occur.

Assuming we have now designed and built our motor on the lines discussed here, it will be necessary to examine the degree of excellence attained. This is best done by brake tests. It will not be necessary to run the motor at a constant potential ; indeed, in practice this is often a matter of no little difficulty. Let our motor be series-wound, and designed to run on a lighting circuit of 100 volts. Measure the ohmic resistance hot. Arrange the motor with a Prony or other absorption brake, and put a suitable resistance in series with the windings, so that any desired E.M.F. may be obtained within the limits of supply.

First, run the motor light—*i.e.*, without the brake, at the highest speed required of it, and note the terminal volts and the amperes. Then place the brake in position and screw down the blocks. Take readings with different loads, varying the current by intervals of one ampere, and noting the corresponding volts and speeds. When the maximum load is reached, we have all the data for calculating the performance of our motor. Arrange ten columns with following headings :—

Speed.	Weight.	Volts.	Amp.	B.H.P.	E.H.P.	Efficiency.	$\frac{E}{n}$	$\frac{e}{n}$	$\frac{\text{B.H.P. } 746.}{n\,c}$

The first four are filled in from the observations of the test. The B.H.P. is calculated from the speed, the brake load, and the brake constant. The E.H.P. and the efficiency speak for themselves. We have now three columns left. From these we purpose to plot three curves that will show how far our method of design be successful.



The first, $\frac{E}{n}$, is the terminal E.M.F. divided by the speed obtaining for the particular value of E.

The second, $\frac{e}{n}$, is the so called back E.M.F. ($= E - C\,R$) divided by the same value of n.

The third, $\frac{\text{B.H.P. } 746}{n\,c}$, is really of the same order, viz., a definite number of volts absorbed per revolution *in actual work on the brake*.

This requires some explanation. Note that the B.H.P. multiplied by 746 gives the available useful horse-power in watts, *i.e.*, a quantity that can be expressed by the symbol C E. We know the current flowing for any load, but do not know the exact fraction of the applied E.M.F. usefully employed for external work. But if we divide the B.H.P. expressed in watts

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by the known currents, the value of the unknown volts is given. This quantity is divided by n to reduce it to volts per revolution. The efficiency is thus given us by dividing $\frac{\text{B.H.P.}\ 746}{n\,c} / \frac{E}{n}$, or efficiency $= \frac{\text{B.H.P.}\ 746}{c\,E}$. We now take a piece of squared paper, and set off the current as abscissæ, and for ordinates the volts per revolution. Then we plot against the several currents the corresponding values of $\frac{E}{n}$, $\frac{e}{n}$, $\frac{\text{B.H.P.}\ 746}{n\,c}$. This gives us three curves. Two of these rise from the origin 0; but the third, the curve of useful work, starts at that particular value of c which is just sufficient to overcome the static resistance of the motor. It will be noted that these curves tend to diverge from parallelism as the load increases. They show on inspection two things of great importance in motor design. The height of the ordinates between $\frac{E}{n}$ and $\frac{e}{n}$ show the E.M.F. lost over the ohmic resistance of the machine when heated to its normal temperature. The distance between $\frac{e}{n}$ and the lowest curve $\frac{\text{B.H.P.}\ 746}{n\,c}$ shows the E.M.F. lost from all other causes, viz., material and magnetic friction, and by induction. These three curves give at a glance the value of the motor as a converter of energy, and they show not only where the losses occur, but they give the magnitudes. The several quantities are divided by n, simply because it is practically difficult to make a test with constant speed. Since n is proportional to $\frac{\text{B.H.P.}\ 746}{n\,c}$ and is the same for the three ordinates corresponding to each value of c, no error of importance is introduced.

We now can see whether the losses, other than those due to the internal resistance, are excessive. The heat waste is a necessary evil, and can only be reduced within certain limits. The area between $\frac{e}{n}$ and the work curve can, however, be made very small. In a really well designed motor this area should always be considerably less than that proportional to $C^2 R$.

If the losses due to friction and Foucault currents be larger than those caused by the copper resistance, the machine is badly designed. Our motor, however, will not only have a small value for $C^2 R$, but its other losses will not exceed $\frac{C^2 R}{2}$.

With these rough notes I close my Paper. I may not have told you much that is new, but I hope to have made clear some of the more general difficulties, and to have put the design of motors on a simple engineering basis.

READING THE BAROMETER AT A DISTANCE.

The following apparatus for reading the barometer at a distance has been devised by M. G. Kornmüller, of Ghent. Fig. 1 shows

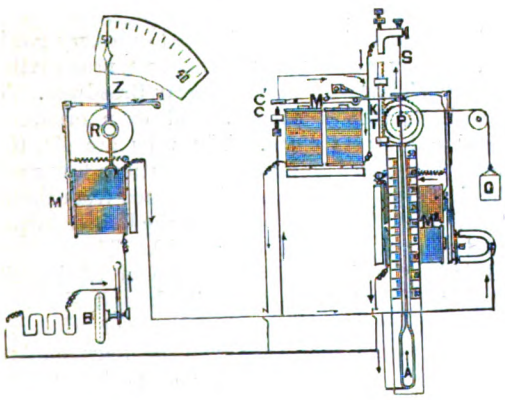

FIG. 1.

FIG. 2.

the receiving instrument, and Fig. 2 that at the distant end. On depressing the key B the current from the battery flows through the magnet M′ and the ratchet wheel R, carrying the pointer; Z is thereby advanced one tooth. The current also passes at the same time through M^2 at the distant end, and the ratchet wheel P is also advanced one tooth. By a "trembling bell" arrangement on M^2 the current is made and broken continuously, and the two ratchet wheels therefore rotate synchronously. T is a rack gearing with a pinion attached to the ratchet-wheel P, and by its rotation is pulled downwards against the action of the counter-weight G. This rack carries a platinum wire, S, which fits loosely into the thermometer tube A, the mercury in which is connected to the circuit as shown. As soon as the wire touches the mercury it makes the circuit of the magnet M^3, which, attracting its armature, lifts the catch K, and the rack and wire are at once raised again by the counterweight G. M^3 being made of much lower resistance than M^2, takes the greater part of the current, and M^2 is rendered inoperative; the make-and-break action, therefore, ceases, and the pointer at the receiving end remains at rest, indicating the height at which the mercury stands at the distant station. In short, when the key is depressed a make-and-break action is set up, advancing the two ratchet wheels synchronously until the wire touches the mercury, when the indicator stops, and the mechanism at the distant end resets itself. In order to avoid a spark when the wire leaves the mercury it will be seen that as soon as the armature of M^3 is attracted it makes its own circuit at C C′ independently of the mercury. The push button B is arranged so that releasing it mechanically resets the pointer to zero.

LEGAL INTELLIGENCE.

In re Gaulard and Gibbs' Patent.

COURT OF APPEAL.—SATURDAY.

(Before LORD JUSTICES COTTON, LINDLEY and LOPES.)

This is an appeal of Lucien, Gaulard and others against the judgment pronounced by Mr. Justice Kekewich on July 9th, 1888*, in the case of a petition for the revocation of certain letters patent which were granted to Messrs. Gaulard and Gibbs on the 13th of September 1882.

Mr. Aston, Q.C., and Mr. J. C. Graham appeared for the appellants, Messrs. Gaulard and Gibbs; and Sir Horace Davey, Q.C., and Mr. Fletcher Moulton, Q.C., for the plaintiff, Mr. Sebastian Z. de Ferranti.

Mr. ASTON, in opening the appeal, said that the hearing in the Court below lasted some time, and eventually the learned judge came to the conclusion that for want of good subject matter the patent was bad, and therefore ought to be revoked. His lordship also said, though he did not give a special judgment on the point, that the invention as described and claimed was wanting in novelty, and the learned judge especially referred to the specification of Harrison. Against that judgment Messrs. Gaulard and Gibbs now appealed. He should endeavour to show that that judgment was erroneous, for the following reasons:—First, that Messrs. Gaulard and Gibbs described clearly in a sufficient specification a new and useful system or process of distribution of electricity from a central supply station to local stations placed on a long main wire. Secondly, that no prior use of such a system had been, or could be proved, because it did not exist prior to the date of the patent. No prior description could or had been produced which without important alterations or additions could be made to fit the description of Gaulard and Gibbs' patent. His third point was that the Court below had been misled by applying what had been called the mosaic construction, and assuming that Messrs. Gaulard and Gibbs had used parts of prior publications. His fourth point was, that the learned judge in holding that the patent of Gaulard and Gibbs was bad for want of good subject matter, failed to give proper effect to the uncontroverted evidence given on that occasion. The learned judge had mainly based his judgment upon alleged want of subject matter in the patented invention.

The problem to be solved is this: There being a central station at Edgware-road, how was electricity to be distributed along a main wire so as to supply local installations on a line, for instance, of fifteen miles. Up to the date of the patent in 1882 there was no way of doing it. There had been no described way of treating anything like a line of fifteen miles by supplying from a central station electricity which was to be taken to stations 1, 2 and 3 along the line at two, three, or five miles interval. The first thing to be done was to state what was the generator to be employed. Dynamos sending alternating currents were known, and these would do provided they had those alternating currents of high tension. Anybody at the time of Gaulard's patent might have gone wrong; and so far the majority of the so-called anticipations did go wrong, because one said he would have his generator a battery, another a magneto-electric machine with direct current, and another that he would have an alternating machine, but he did not say what kind of current. He (the learned counsel) would prove that high-tension currents were required, and alone would do. When they came to his learned friend's chief witness (Sir Wm. Thomson) they would find that in order to send a pressure along a main wire to supply installations at long distances, they must have a high tension of at least 2,000 volts. However, the problem was not solved by simply telling the world what was the right generator, and that they must have a long main wire along which to send that electric energy, for Sir Wm. Thomson told them that 2,000 volts was a man-killing energy; and Sir William said that 200 volts was the highest amount that they could employ for the purpose of lighting houses or shops. But there was another reason: The voltage required for the incandescent lamp varied in the Swan from 50 volts to 100 volts in the Edison, but none of them went above 200 volts. They could not send through those lamps the same current that it was absolutely necessary to employ in order to send their current through 15 miles of wire. How was that problem to be solved? The patentee told them. Place at intervals along their main wire a secondary generator of a special character. The machine itself must supply the currents at a potential to supply electric energy for fifteen miles, and which drove it with a velocity that alternated 16,000 a

* See *The Electrician*, July 13th, p. 316.

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minute. That electricity would not do for local installations, but that electricity would induce at the local stations a suitable current which might be there safely utilised to do the work if they had a proper secondary generator. Induced electricity was electricity set up in a collateral wire by variations in the electricity which was allowed to pass through a main wire alongside of which the collateral wire was laid. The resistance of the secondary wire was very much greater in the Ruhmkorff coil, because the resistance increased as the area diminished. The patentee had to solve the problem of supplying lamps of various characters at various stations more or less. Consequently they had to do two things, they had to describe an induction coil of a special character that could be adapted to various installations, and to glow lamps and arc lamps. They must have a secondary generator capable of adaptation, not like the Ruhmkorff coil, which once made up was made up for all time. They must have them so that the induction coils themselves should not set up in their cores local currents that were injurious. Although the patentees had not claimed secondary generators, still they had indicated the kind of secondary generators that must be used to make it a success, and the kind of electricity as regarded its condition that must be sent along these wires. When that system was put forward in a practical form, and when the electric lighting world was told that that solved the problem it, was not accepted, but it was received with doubt and incredulity and ridicule. He would tell their lordships why. Sir William Thomson pointed out that wherever they had induced electricity to do that, and they caused that induced electricity to manifest itself. by a current going through a primary wire, they had to pay for it. Consequently a doubt which pressed upon the minds of electricians was, if they had an alternating current of 2,000 volts sweeping from pole to pole of their dynamos to and fro, and they tapped that energy at local stations by using secondary generators or induction coils, they would not get anything like the energy they wanted in these induction coils. That was the way in which scientific persons received the statement that these secondary generators could be so constructed as to employ the induced electricity excited at the local installations to do local work. But the thing was done at the Aquarium and at Edgware-road. At the latter place they had a dynamo machine, sufficient alternating currents, and a main wire 15 or 20 miles long; and there were four or five local installations, and 50 to 100 lamps, and they all worked. Dr. Hopkinson gave in evidence that he found the return in energy in the secondary generators made and used by Gaulard and Gibbs as 86 per cent. The moment Dr. Hopkinson told the world that the patent was a success what happened? Why, what always happened. Rivals said that they had rummaged among the Blue Books, and they had found it there anticipated. These rivals could not find a single instance of its practical application. His learned friends would refer to seven or eight patents as disclosing an anticipation of his clients' patent; but, whilst they contained some part or some element of the combination, he submitted that not one of them had the combination. The specification of Messrs. Gaulard and Gibbs, as it originally stood, was open to objection by reason of a doubtful interpretation that might be put upon the language there used. Consequently, their lordships would find that certain lines were struck out by disclaimer, and the claim to the secondary generators as a separate element was also disclaimed. The title of the specification was "A New System of Distributing Electricity for the Production of Light and Power." It was not a new system of generating electricity; it was not a new system of lighting; but it was a new system of distributing electricity for the production of light and power. There was a very sharp distinction between a system of distribution and a method of lighting a single lamp or a group of lamps. The complete specification said, "This system consists of the employment of an alternating current produced by an electrical dynamo machine, and determining by its passage through a number"—it originally stood an unlimited number—"of electrical generators of special construction. The formation of induced currents of the requisite kind, on which the quality and value"—that was to say the quality and value of the currents—"depend only on the construction of the secondary coil, and the several electrical generators."

LORD JUSTICE LINDLEY: Do your opponents say that this alteration or disclaimer extends the right?

Mr. ASTON: No; they cannot say that, because Mr. Justice Kekewich told them that they had not put in the pleadings.

SIR HORACE DAVEY: I do say that the amended specification treating that as if it was the original specification was of a different kind of invention from that described in the provisional specification.

Mr. ASTON: I say that my friend has no cross appeal, and the learned judge has decided that in my favour.

LORD JUSTICE LINDLEY: Did the learned judge go into that point?

Mr. ASTON: Yes. Let us suppose that I am open to that. I say that the statement "unlimited" may fairly be construed as indefinite—that is to say, not limited to any precise number. If unlimited were construed as limitless, then it would be untrue. The learned counsel then proceeded to say that the petitioner objected to the amended specification because, first, it was not useful; second, it was not new; and, third, that it was not the subject matter of a patent. He did not think that they heard anything about the sufficiency of the specification.

Sir HORACE DAVEY: Oh! Where do you show the class of secondary generators?

Mr. ASTON: It is a secondary generator which has a divided core so that Foucault currents should not be there. It is a secondary generator which consists of secondary or primary wires, and secondary wires having convolutions in juxtaposition, so arranged that you can suit them to the varied work which they would have to do in the varied installations. My friend says that is not so.

Mr. MOULTON: That was not suggested in the Court below.

Mr. ASTON: We said that we believed for the first time that the secondary generators made by Gaulard and Gibbs were connected with an alternating dynamo on a long main wire. Am I right in saying that these secondary generators do consist of primary wires and secondary wires with varying convolutions? Sir Horace Davey interrupts me and says "They all do." I say they do not. Then I say that they must have divided cores, and nobody said that they must have divided cores. I challenge my friend to point out a single person who said: "Now mind when you use an alternating dynamo at high tension, take care that your induction coil has divided cores." There is not a single instance of user in one of the seven or eight prior specifications put in. Sir Wm. Thomson, Mr. Ferranti, Dr. Fleming, and everyone of the witnesses were asked, "Did you ever see one of those crude anticipations," and they said "No."

LORD JUSTICE LINDLEY: You say that the central exciting core is a divided core.

Mr. ASTON: Yes; and Sir William Thomson says the same. When I come to Sir William's evidence you will find that he distinctly says that solid and divided cores were known. There was a man named Fuller, a well known electrician in the United States, who took out a patent under the name of Lake, and that patent was relied upon as an anticipation. But it is very remarkable that where there is any reference to an alternating current supplied by an alternating machine, the core of the induction coil is always solid.

Mr. MOULTON: You own chief witness said it was not.

Mr. ASTON deprecated these interruptions.

LORD JUSTICE COTTON asked if Sir Horace Davey was going to say anything about the specification as amended by disclaimer.

Sir HORACE DAVEY: The particular form of objection which I took was this: Assuming that the specification as now amended was the original specification which had been originally filed by the patentee, it describes an invention different from the provisional specification.

Mr. ASTON argued that in that case his learned friend should have gone for a cross appeal.

Their Lordships intimated that Mr. Aston would have to meet Sir Horace Davey's point; and the Court then adjourned.

SECOND DAY, THURSDAY.

Mr. ASTON resumed, addressing himself to the objection that the specification failed, as the complete specification was not in conformity with the provisional specification, and argued that there was no substantial distinction between the wording of the provisional and complete specifications, and that therefore the objection was bad in law. The learned counsel then read over the judgment delivered by Mr. Justice Kekewich, and the Court adjourned at luncheon time for the day.

Mr. ASTON then proceeded with the reading of the evidence of Dr. Hopkinson, the cross-examination being read by Sir HORACE DAVEY.

LORD JUSTICE COTTON observed that certain things were supposed to be claimed because they were necessary to success, but it appeared from the evidence that the patentee (Gaulard) did not know they were necessary. Under those circumstances, it was a question whether he had given a sufficient description of the invention in his specification.

Mr. ASTON: That, my lord, I shall have to deal with by-and-bye.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 5th*, 1889.

The local Edison Illuminating Company has just begun to supply current from its up-town stations, and from this time the capacity of the plants will be gradually increased until they reach their limit. The two buildings, which are almost exactly alike inside and out, are situated in a very good section of the city, one being in Twenty-sixth-street, near Sixth-avenue, and the other in Thirty-ninth-street, near Broadway. They are five stories high, with a massive and even ornate front of granite, brick, and terra cotta. The walls are 4ft. thick, and nothing has been spared to render the stations fireproof. Some idea of the fireproof qualities may be formed from the fact that in a total cost of $140,000 for building, the bill for carpentering, glazing, and painting is less than $4,000. The stair ways are stone and iron, the floors and roof are of tiled arches, and the sidewalls are lined with glazed brick and slate. Taking the Twenty-sixth-street station as a sample of what is done in both, it may be stated that there will be fourteen Armington and Sims engines, 250 horse-power each. Both of these engines will run two dynamos, making twenty-eight machines in all, each capable of supplying 1,250 16 candle-power lamps, so that the total capacity will be some 35,000 lights actually running at one time from each station. A remarkable feature of the plant is the manner in which the different departments are arranged. The boilers, for instance, are on the third floor; the water tanks are immediately above, and the coal pocket is on the top floor. The pocket will hold 1,200 tons of coal, and it is so arranged that coal is delivered from it by a shoot in front of any two boilers, in such a way that there are never more than a few shovelfuls of coal on the floor of the boiler room. The water tanks are of equally large capacity, and will hold, I

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believe, more than a full day's supply. On the second floor in the middle is the general workshop and the meter room, and at each side are the depositing ashpits of the boilers. This is a very neat arrangement. Immediately under each boiler, on the floor above, is a hopper with a bottom which opens by a lever. Under these hoppers runs a little railroad track, up and down which travels a small ash car. Once a day the hoppers are emptied into the car, which is then brought to the front of the building along the track, and is emptied into another hopper opening into a passage leading into the street. From these larger hoppers the ashes are dumped into a cart once a day and carried away. As they have been previously damped there is no dust, and the whole system works like a charm, there being no shovelling of the ashes at all. In the dynamo room the dynamos are grouped in pairs along each side, and the controlling and regulating apparatus is brought together on the central platform or gangway, up and down which the attendant can walk, with every dynamo and instrument in full view. For the distribution of the current that is generated in this and the other station about 165 miles of conductors have been laid. The company are so well satisfied with the prospects that they have purchased ground for another station a mile or two further up town, in Fifty-third-street, not far from Central Park.

You may remember that the United States Illuminating Company brought a suit recently against the Board of Electrical Control to obtain an injunction restraining the Board from interfering with its wires. Judge Lawrence, of the New York State Supreme Court, says that, after the examination of the papers in evidence, he is of opinion that the company is not entitled to an injunction, and that he "sees no reason for interposing the strong arm of the law to arrest the progress of a great public work, the speedy completion of which is desirable for the safety and convenience of the people." This is pretty conclusive, and when it is taken in conjunction with the advent in office of the new Mayor, who supports the Subway Board, it will be seen that matters are likely to go hard with companies that will not acquiesce quietly in the new order of affairs. While the attitude of the Court and of the Mayor may be altogether such as the law requires, it is a great pity that the conduits are not so good as they might be, for then there would be much less opposition to their use. The second annual report of the Board of Electrical Control to the Governor states that a total length of 240,155ft. of trench has been excavated in this city for the laying of subways. It is estimated that the total capacity for telegraph and telephone service is 34,655 miles of wire, and that the capacity for light and power service is nearly 600 miles of wire. These figures are exclusive of the Edison underground service, which, though under the jurisdiction of the Board, has been laid independently. The Board reports that it has removed 776 poles and 946 miles of wire. The companies that have gone underground are now operating 4,453 miles of wire. The report admits that there has been an increase during the year in the mileage of overhead conductors; but it points out that there has been a great increase in electrical service, the growth in electric lighting alone being estimated at more than 200 per cent.

The reference I have made above to the fine new electric light stations in this city reminds me that an addition has been made to the list of telephone palaces. New York, Chicago, and other cities have splendid exchange buildings, and St. Louis now falls into line. The Bell Telephone Company, of Missouri, have just adopted a plan for the erection of a building in St. Louis, which is to cost $125,000. It will be seven stories high, and will be built of stone, rough dressed, presenting a most handsome and solid appearance. It is the intention to rent out the first five stories and part of the sixth. The executive offices of the Telephone Company are to be on the sixth floor, and the whole of the seventh floor will be occupied by the exchange room and its adjuncts. Under the skilful management of Mr. Geo. F. Durant, the telephone service in St. Louis on the Law system has grown very rapidly and has been very efficient.

The daily *Graphic* of this city, which is, I believe, the only illustrated daily paper in the world, has just printed a very interesting article on electric power, taking for its theme the growth of the Daft Company and the work of its electrician, Mr. Leo Daft. It may not be generally known that, as appears from this article, Mr. Daft is an Englishman, who was born in Birmingham in 1843. When the family moved to London the boy early showed an interest in electrical matters and other devices, and came under the notice of Mr. Siemens, who took an interest in him and helped him along. Mr. Daft came to this country as a civil engineer, and after engaging in railway work, started a small electrical factory at Philadelphia. In those days there was no great demand for electrical apparatus, and he went into other work until 1880, when the renewed interest in electric light and power gave him a new opportunity of which he did not fail to avail himself. Through the instrumentality of the Daft Electric Light Company, Mr. Daft now has the advantage of large works at Marion, N.J., and has been enabled to take no small share in the development of electric power in this country. Daft motors are in use in every part of the Union, and it is said that in this city alone some 1,500 horse-power is developed through their instrumentality. There are also Daft electric roads running at Baltimore, Los Angeles, Pittsburg, Meriden, Mansfield, Asbury Park, Ithaca, Easton, and elsewhere, as well as the experimental section of the Ninth Avenue elevated road in this city upon which the motor, "Ben Franklin," of which an illustration was recently given in your columns, is operated.

Now that the law has gone into effect requiring that electricity shall be used in this State as the means of capital punishment, the newspapers are busily engaged discussing the *pros* and *cons* of the subject, and expressing their views as to the feasibility of the law. As regards the parts of the law which provide that none of the newspapers shall give details of these electrical executions, it is safe to say that they will be a dead letter from the outset. The newspapers are determined that they will record such executions as fully as they would those of any other method, and they denounce as unconstitutional the clause which says that they are to be punished if they endeavour to gratify the curiosity of their readers. Such a provision acts simply as a stimulus to our enterprising newspaper men, just as it would to those in England, and the reports are likely to be fuller from the fact that they are forbidden. With respect to the plan by which the sentence shall be inflicted, great doubts still seem to exist as to the best course to be adopted. Among electricians here, the idea of using electricity for this purpose is not relished, and one cannot blame a body of men for resenting anything that may tend to lower the dignity and status of their profession. You have already published some of the plans proposed, including that of the Medico-Legal Society, which in some way has been constituted a kind of adviser on the subject, and has given evidence that, while it may know something of medicine, it does not know too much about electricity. The *Electrical World* has expressed its opinion against the plan that has been recommended, and the *Electrical Engineer* is also opposed to electrical executions. When a man is about to lose his life it is little enough to ask that he should be allowed to die in a gentlemanly way, but it would seem that electrical execution would reduce the criminal to the level of the merest brute under torture of uncertain severity and duration, and would turn the representative of the State inflicting the last dread penalty into a person who is, perchance, risking his own life, and subjecting his profession to unnecessary odium. The whole matter is in bad shape, and as we have already one or two candidates for the executioner, it is doubtful how they will be disposed of. As the *Scientific American* says, "The law has been passed, and no provision has been made to carry it out. Apparatus is not provided, no competent specialists have been appointed to superintend its administration, and in the present state of affairs the present law appears to amount to little more than in indefinite suspension of the death penalty for murder."

An important suit has been brought in the State of Pennsylvania by the State officers against the Western Union and Baltimore and Ohio companies for consolidating. It is alleged that the charter of the Baltimore and Ohio Company in Penn

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sylvania contained a provision that the company should not be sold or consolidated with any other company, and on that ground the Attorney General claims a decree of forfeiture and escheat of the lines, property, and franchises of the Western Union Company in that State. In some quarters it is believed that this move is due to the recent triumph of the Garratt interest in the election of the new president of the Baltimore and Ohio Railway Company; but it is stated, on the other hand, that the Attorney General has taken the step of his own free will, and would have moved in the matter over a year ago had he been in possession of positive proof establishing the fact of the consolidation. Dr. Norvin Green, the president of the Western Union Company, takes the matter placidly, and says that there is no good ground for the action. He holds that there is no actual consolidation, as the Baltimore and Ohio organisation is still maintained separate and competing. Moreover the Western Union Company, when it made its purchase of the Baltimore and Ohio plant, did not buy that portion that was operated in the Pennsylvania charter. The Pennsylvania Company was not included in the purchase as such, and the Western Union expressly refused to buy it on account of the stringent State charter. Furthermore, Dr. Green says that if the State law is invoked in this case it would have no effect in the face of the United States law, the United States Supreme Court having decided over and over again that telegraph business comes in the category of inter-State commerce, and cannot be interfered with by State action or statute.

CORRESPONDENCE.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At a recent meeting of the Society of Telegraph-Engineers and Electricians a discussion was raised by Mr. Preece on the present method of electing the Council of the Society. It happens that I have devoted some thought to the subject, and as there is little or no probability of the discussion being resumed, I ask to be allowed to give a short statement of my views in your columns.

Instead of adopting the practice followed by nearly every other learned Society, of recommending for election only a sufficient number of persons to fill the vacancies, the Council has, of late years, submitted lists containing many more names than are required for the purpose, leaving it to the members themselves to make a selection from those nominated. Mr. Preece said that there was a difficulty in finding men of eminence and position who would submit to this process of competition. I am not surprised to hear it. Many such men, however highly they might value the honour of a seat upon the Council, would no doubt object to be put into public competition for it under any circumstances whatever. But when we consider the actual conditions of the competition their hesitation to take part in it becomes even more intelligible.

It implies no want of respect to the gentlemen whose names are contained in the list of members and associates to say that the great bulk of them are, as individuals, quite incompetent to appreciate the relative qualifications of the several candidates for election. With such an electorate it might well happen that the inventor of a widely-advertised ampere-meter, for example, would stand a better chance of success than a man whose claims were of a far more solid and substantial though less popular character. The latter might naturally be unwilling to court rejection, which, even if it did him no serious harm, would at all events not add to his reputation.

But it is not only, or mainly, from the candidate's point of view that I take exception to the method at present in vogue. I consider that in adopting it the Council are shirking their responsibilities, and seeking to relieve themselves of a part of their reasonable duties. The position which they hold in the society, together with the opportunities they have of organised discussion and inquiry, give them immense advantages in adjudicating upon the relative merits of possible candidates. If they know who are the best men to fill the vacant seats, they are bound, in the interests of the society of which they are trustees, to name them. If with all their advantages and opportunities they are unable to decide, how can a mere private member be expected to do so? For my own part I decline to make the attempt, and straightway consign my balloting list to the waste-paper basket.

The present system was avowedly designed to meet the dissatisfaction which was somewhat freely expressed a few years ago with regard to the constitution of the Council. As a matter of fact, it does nothing of the kind, and if the former state of dissatisfaction no longer exists, its disappearance is due to other causes. What was, I think, reasonably objected to was the persistence with which certain members of the Council (useful and able men, no doubt) clung to their seats year after year, to the exclusion of others equally competent. A frequent and liberal infusion of new blood is for many obvious reasons desirable, and I believe it would be an excellent thing if the custom were established of placing upon the balloting list the names of only a bare majority of the existing Council, thus limiting the average tenure of a seat to a term of about two years. By this course not only would the Council be brought into more intimate and harmonious relations with the Society generally, but it would become possible to distribute the honours, the dignities, and (let us be candid) the commercial advantages of office among a larger proportion of its members.

There is another matter in which I think reform is sorely needed. The volumes of our *Journal* constitute a vast treasure-house of exceedingly valuable matter; but it can hardly be denied that they are at the same time the receptacle of an appalling amount of inane trivialities, not to say downright rubbish. This is the consequence of the practice of reporting discussions *verbatim*. At the Royal Society no report whatever of a discussion is permitted. It was found that so long as the learned Fellows were exposed to the liability of having their unconsidered words taken down in writing, they hesitated to speak at all, and reporting was prohibited in order to promote freedom of discussion. It is possible that a few (very few) words of wisdom may have been lost to our own Institution from a similar cause; but with us the evils resulting from copious reporting are, generally speaking, of quite the opposite character. Men who, having nothing to say, would in the absence of the reporter wisely hold their peace, cannot resist the opportunity which the *Journal* offers of "keeping themselves before the public," especially when from a business point of view there is something to be gained from publicity. Having no information to impart with reference to the subject in hand, they are content either to reiterate the remarks of previous speakers, or to enlarge upon any irrevelant topic that occurs to them.

The remedy is simple. We cannot afford to dispense altogether with reporting, for there are many speakers (including some of those who speak most frequently) whose remarks are always well worthy of being recorded. But the shorthand writer's transcript, instead of being printed in its entirety should be submitted to a competent sub-editor, whose duty it would be to separate the wheat from the chaff, and to prepare short summaries of all except the most important speeches. In nearly all cases considerable abbreviation would be advantageous; in not a few it would be possible to give the pith of several pages of verbiage in as many lines. If this were done, not only would the standard of our discussions and of our journal be improved, but a large saving might be effected in the printer's bill, sufficient, no doubt, to provide ample remuneration for the sub-editor. In these days of technical education there would be little difficulty in finding a young man perfectly qualified to fill such a post. Cases of doubt, when they arose, might be referred to the secretary or the editing committee (if it still exists), who would, of course, be ultimately responsible.

It might be urged that the proposed plan could not be carried into effect without the risk of giving offence to individuals, and wounding susceptibilities. To some extent this would perhaps be unavoidable, especially in the earlier days of the reform; but any objection arising from such a cause would be far more than outweighed by the gratitude of those whose duty it is to

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read the *Journal* on having their present wearisome task lightened, and by the disappearance of all real ground for that suspicion of contempt and ridicule with which there is at present an undoubted tendency to regard our proceedings.—Yours, &c.

SHELFORD BIDWELL, F.R.S., M.Inst.E.E.

January 14th, 1889.

MR. EDMUNDS' METHOD OF MAINTAINING CONSTANT CURRENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the course of his Paper on "A System of Electrical Distribution," read before the Society of Telegraph-Engineers and Electricians on the 22nd November last, Mr. Edmunds made a statement that no governor was required on his steam engine, which automatically increased its speed as the work was put on, and, *vice versâ*, slowed up on the work being taken off. Evidently others besides myself were a little in the dark as to how this was possible, for Mr. W. H. Preece asked for an explanation. Mr. Gisbert Kapp, who followed, opened his remarks by saying that "Mr. Bernstein" had "already done it," and "it is a perfectly easily understood thing . . ." "The pressure against the piston being constant, the torque on the armature is constant; and as the field is also constant, the current must be constant . . ."

As I was unable to accept this as an explanation, I subsequently rose, and, in the course of other remarks, asked for further information.

Being unable to attend the next meeting of the Society, I turned to your columns of the 21st ult., but was much disappointed to find that, beyond saying practically it is easy if you only know the way, Mr. Edmunds had ignored the remarks of Mr. Preece and myself, and I therefore awaited the publication of the *Journal* of the Society to see if I had misapprehended the conditions, and was almost surprised to find that such was not the case.

These conditions are that a boiler with constant pressure maintained in it drives an engine without a governor, and between itself and which nothing is inserted except the ordinary starting and stopping valve. This engine with the boiler pressure acting "direct on to the piston"—drives a separately excited dynamo, and as long as these conditions are observed speeds up as work is put on, so that a constant current is always maintained in an external circuit whose resistance varies from short-circuit to an unstated amount, say, such that 2,000 volts are required to do it; or, in other words, and taking Mr. Edmunds' own statement of current, 70 amperes. The engine, the starting valve of which has been opened so that it drives the dynamo just fast enough to generate 70 amperes at, say, 10 volts (= 700 watts, say, one brake-horse-power), will, without attention to anything except the maintenance of a constant steam pressure of 70lb. on the boiler, and without alteration to the starting valve, *increase* its speed until it gives 70 amperes at 2,000 volts = 140,000 watts, or, say, 200 brake-horse-power.

If the pressure of steam acting on the area of the piston is just sufficient to drive that piston so many feet per minute, how is it that the same pressure is capable of driving the same piston at double or treble the speed with the same resistance per turn to overcome, *i.e.*, do the same work in half or one-third the time?

Why is it necessary to use a separately-excited dynamo? If the current be constant, are not the watts lost in the fields of a series machine constant also?

Finally, if the adoption of a constant boiler pressure and a separately excited dynamo is all that is necessary to ensure a constant current, why trouble about elaborate engine governors as Willans', Richardson's, and others, or dynamo regulators as Thomson-Houston's? Why spend large sums on big engines when all that is necessary is to get one capable, with a certain boiler pressure, of driving a dynamo which gives some 50 volts and 10 amperes? An arc lamp can be driven at that speed. Two, ten, twenty arcs only require additional speed, for "equal current electromotive force is very nearly exactly proportional to the velocity of rotation," says Dr. S. P. Thompson in his "Dynamo Electric Machinery." The work per turn is the same, and within the limits of speed to which the engine can be worked without flying to pieces, two, ten, twenty horse-power can be got out of a one-horse engine.—Yours, &c.,

DOUGLAS C. BATE.

STANDARDS OF LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your editorial remark that "I am a firm adherent of the venerable wax candle, and stoutly maintained at the Society of Arts that it was all the most enlightened could desire, &c.," I take to be banter—at all events, it is an amusing misrepresentation. As a fact, I advocated the Amyl Acetate Lamp of V. Hefner-Alteneck, which I had the honour to bring to the notice of the authorities some four years ago through the courtesy of Messrs. Siemens. The experiments I then made led me to express a high opinion as to the steadiness of this unit, and the official trials since made have amply confirmed my results. With some minor changes I believe this lamp can be adapted to serve as a standard of light accurate enough for all practical purposes.

Most of your readers cannot ascertain what I said on the "Standard Candles," and if I remain silent might take your remarks seriously. May I, therefore, say that I quite agree with Mr. Vernon Harcourt and every other authority in condemning the present sperm candle, but I further agree in his forecast that it is likely to remain the Parliamentary standard for some time to come. Now, I contend that while we have to use sperm candles every care should be taken to ensure the minimum variability, and the question is whether more uniform candles cannot be supplied.

At present any candles running six to the pound and professing to be of sperm, made anyhow, by anybody, and with any kind of wick, may be taken as standard candles, provided only they burn anywhere within a 10 per cent. range of 120 grains per hour. I say *professing* to be sperm, although wax is always added to "break the grain" of the spermaceti. Remembering that the demand for these candles is small and their manufacture distributed, can we wonder that they are badly made and very irregular. Obviously they ought to be made at one place, under some control, and with a special view to uniformity.

The serious difficulty is the legal one, seeing that any official control over the manufacture would be illegal, or rather *extra legal*, and might be resented by the interests concerned on the ground that photometric tests would be more stringently interpreted, occasionally, no doubt, to their disadvantage. On the other hand, there are compensatory advantages in a steady unit, and it would be pleasing to hope that representatives of the lighting industries might be appointed to confer with the authorities of the Board of Trade and arrange for the issue of standard candles with some little title to the name. Of course the use of these could not be made compulsory, but there is little reason to doubt they would be eagerly sought for.

I have had a lengthened experience of official photometric testing with the present candles, and I can confidently affirm that I would complain to any chandler who supplied me with the paraffin candles for everyday use that were half as bad and burnt with such fantastically distorted and irregular wicks. I do not wonder at the unsatisfactory results.—Yours, &c.,

M. WHITLEY WILLIAMS.

Ponder's End, London, N., January 15, 1889.

[On referring to the *Journal* of the Society of Arts we find that our correspondent is entitled to complain that the spirit of his remarks was not fairly represented in our note of last week. In fact, Mr. Williams's references to the standard candle were intended to show how to make the best of a "standard" which he agreed with other speakers in condemning as radically faulty. We regret not to have observed this at the first.—ED. *E.*]

BATH ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The tenor of Mr. Massingham's letter affecting my company in your last issue, and the sympathetic comments thereon in the electrical journals being calculated to create the im-

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pression amongst local authorities throughout the country that they are likely to be denied the benefit of competition in determining to whom they should allot the areas within their jurisdiction, I shall be obliged by your kindly giving the widest publicity to the announcement that the House-to-House Electric Light Supply Company, Limited, whose engineers have hitherto constructed the only central electric lighting stations for the distribution of electricity throughout an extended area by means of underground mains, is prepared to place its experience in both electric light supply and central station construction at the disposal of local authorities everywhere in the United Kingdom.

The House-to-House Company, as its name implies, has no local predilection whatever beyond the usual commercial inducement, and it will be prepared either to apply to the local authorities for permission to apply to the Board of Trade to undertake the business of supply within their areas on its own account or in conjunction with local capital, or to erect for local authorities or independent supply companies central stations on the model of its own at Kensington, which is by general admission the most perfect of its kind.

To this end my company endeavours as far as possible to watch the progress of central station development in all towns in the United Kingdom which, in virtue of their population, present a promising field for the electric light, and its letter to the Bath City Council was prompted by the report of the proceedings of that body, from which it appeared that a contract had been somewhat reluctantly concluded with Mr. Massingham for street lighting only by means of overhead conductors on the faith of representations to the effect that the present position of electrical science did not permit of the work being accomplished by means of underground mains.

Believing, as my directors do, in the advantage to the public of being supplied under the Electric Lighting Act, which not only requires an underground service, but secures rights to the consumer with corresponding obligations on the part of the supplier, they felt that in these circumstances they would be best protecting the interests of the ratepayers of Bath by applying to the Corporation for permission to apply to the Board of Trade to light a limited area of the city for a limited period under a license tenure, and although the unfavourable editorial comments of the electrical journals on their proceedings have been brought to the notice of my directors, they regret to say that they can see no reason to induce them to abandon the step they have taken.

We cannot attempt to justify our ignorance of Mr. Massingham's claims to the consideration of his fellow citizens. All that we knew about him at the date of our letter to the Corporation of Bath was that he was a most respectable boot and shoemaker in that city, and all that we have since learnt on his own admission is, that so far as electricity is concerned, he is "only an enthusiastic admirer of the light of the future."

My directors venture to believe, however, that such qualifications are inadequate for the proper discharge of the responsibility of undertaking "to introduce electricity into several towns of the West of England;" but be this as it may, they trust that if they should follow Mr. Massingham in extending their operations in the future to such places, the electrical press will not in that event bestow its support on him and withhold it from them.—Yours, &c.,

H. St. John Winkworth, Secretary,
House-to-House Electric Light Supply Company (Limited).

117, Bishopsgate-street, London, E.C.

[We have not hitherto thought it necessary to comment upon the proceedings of the House to-House Company in connection with the lighting of Bath; we therefore presume that we are favoured with the above as a circular letter which will make its appearance simultaneously in the columns of our contemporaries. Since, however, our opinion is challenged, we have no hesitation in saying that whilst the House-to-House Company is of course strictly within its legitimate rights in the action which it has taken, yet in the present phase of the electric lighting industry we are strongly of opinion that, especially in provincial towns, competition of this character is greatly to be deprecated. The investment of local capital in schemes such as that initiated and already successfully carried out at Taunton by Mr. Massingham deserves, and should receive, every possible encouragement. Mr. Massingham is understood to have placed himself in the hands of the representatives of one of the best-known systems, and we fail to see any justification for the insinuation that he is not in a position to carry the undertaking to a successful issue. Since, moreover, we consent to the publication of a letter which savours so much of advertisement, we think it necessary to demur to the statement contained in the second paragraph. The central station at Kensington (? West Brompton) may be "the most perfect of its kind," but until we have had an opportunity of visiting it (which we hope shortly to do), we can scarcely be expected to endorse the statement that this is a matter of "general admission."—Ed. *E.*]

THE ALBION GAS ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue for 11th inst. you state that the Albion gas engine gives a nominal horse-power-hour for 13½ cubic feet, and say that no other gas engine can equal this (if verified). I should say not. The most economical gas engine at present in use burns from 20 to 22 feet per indicated horse-power-hour, including side lights, and $\frac{\text{I.H.P.}}{\text{N.H.P.}} = 2$ or $2\frac{1}{2}$, or consumption = 40 to 50 feet per nominal horse-power-hour. Assume the ratio of $\frac{\text{I.H.P.}}{\text{N.H.P.}}$ to be the same in the Albion as other engines, or about 2, this engine gives an indicated horse-power-hour for 6¾ cubic feet per hour. Economy indeed! And taking the actual efficiency of our present engines as 0·14, the efficiency of this = 0·457. Steam is doomed, for the cost of running is less than ⅓rd!

I fear, Mr. Editor, it is too good to be true. Could the makers give us some data from actual tests? No doubt the high speed tends to give a higher efficiency, as also a reduction in weight and cost, but I fail to see (in your engravings) any points of novelty sufficient to account for the efficiency being more than trebled.—Yours, &c., G. T. P.

Govan, January 13, 1889.

THE LIGHTING OF KIMBERLEY—A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of January 11th I notice that in the account given of the electric lighting at Kimberley the following passage occurs: "The station is also well supplied with ammeters (Slatter's) and voltmeters (Cardew's)."

The "Slatter's" is surely a misprint. We supplied the De Beers Mining Company with instruments made by us under the writer's patent.—Yours, &c.,

J. G. Statter and Co. (Limited).

Alliance Engineering Works, West Drayton, near London,
January 15th, 1889.

THEATRE LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The reply to my protest in your last week's issue from Messrs. Binswanger and Co. is simply evasive. As I have not parted with my own right to manufacture, or determine who shall, the arrangement for theatre lighting and controlling, therefore I have no need to ask for any authority in calling attention to their endeavour to appropriate the arrangement.—Yours, &c., S. Sudworth.

Dorchester and the Telephone.—The Western Counties and South Wales Telephone Company are engaged in a dispute with the authorities of Dorchester which threatens to terminate in the company retiring from the town. The Corporation object to the erection of wires except under their license; the company deny the right of the Corporation to interfere, the wires being carried in all cases at a reasonable height over the streets. If a compromise cannot be arrived at the company intend to withdraw from the borough, rather than enter the law courts.

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MESSRS. WOODHOUSE AND RAWSON'S CATALOGUE OF CONTRACTORS' ELECTRICAL SUPPLIES.

The second edition of this well known catalogue has undergone thorough revision and very considerable extension, and now covers 260 pages of closely printed matter, with more than 300 illustrations. We have no hesitation in saying that it is by far the most complete and exhaustive list of electrical supplies which has come under our observation; in fact it would seem scarcely possible that our electric lighting contractors should discover any class of requirement which is not to be found tabulated in these pages. In the chapters on engines and dynamos we find information relating to a large number of machines of both classes, and including gas, water, and petroleum, as well as steam engines, by many of the leading firms, as well as those of Messrs. Woodhouse and Rawson's own manufacture. The incandescent lamps, switches, and holders of this firm have long enjoyed a wide reputation, and are here described in great variety. Amongst the novelties which are catalogued for the first time in this edition we note the following:—Portable plant, search light plant, electric pumps, tramcars and launches, photometrical and wire-testing instruments, the series traction, and telpher systems, &c. All, or nearly all, the more important apparatus supplied by Messrs. Woodhouse and Rawson has at one time or another been described in the columns of *The Electrician*, and we note with pleasure that the descriptive portion of the catalogue is largely made up of extracts from this and other technical journals.

It would be difficult to over estimate the amount of labour and trouble (as well as expense) involved in the preparation of a work of this description, and the way in which it has been carried out reflects the highest credit upon Mr. Rentell, to whom, we understand, Messrs. Woodhouse and Rawson entrusted the work of compilation.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

17,881. J. S. Crowley. Manchester. Improvements in metal arms or brackets for telegraph or telephone posts. December 7, 1888.

17,893. A. McKeand Cochrane. Glasgow. Improvements in *fac-simile* telegraphic apparatus. December 7, 1888.

17,911. A. H. Fletcher and S. W. Cuttriss. Liverpool. Improvements in apparatus for indicating the period electric lamps are caused to burn. December 7, 1888.

17,915. G. R. Gibson and A. F. Macfarlan. Glasgow. Improvements in the insulation of electrical machines and conductors. December 7, 1888.

17,918. F. E. MacMahon. London. Improvements in electrical counting mechanisms. December 7, 1888.

17,927. A. C. Boursot. London. An electric steering indicator. December 7, 1888.

17,929. J. J. Wilkinson. London. Improvements relating to the application of electricity to Turkish, hot air, vapour baths, and the like. December 7, 1888.

17,961. Siemens Brothers and Co. (Limited). London. Improvements in electric generators and motors (A. M. Taylor, India). December 8, 1888.

17,983. H. W. Bishop and F. Brown. Walsall. Improvements in shade-carriers for electric incandescent lamp-holders, affording more rapid means of fixing and unfixing the shades. December 10, 1888.

17,993. A. Serraillier and G. P. Armstrong. London. An improved portable electric lamp. December 10, 1888.

18,018. H. B. Phillips and W. Mitchell. London. Improved electric automatic fire-alarm. December 10, 1888.

18,022. C. E. L. Brown. London. Improvements in dynamo-electric machines. December 10, 1888.

18,035. Sir William Thomson. Glasgow. Improved apparatus for regulating and measuring electric potentials and currents. December 11, 1888.

18,057. P. M. Justice. London. Improvements in cut-out apparatus for electric lamps (C. Heisler, United States). December 11, 1888.

18,091. W. Aldred. London. Improvements in electro-motors. December 11, 1888.

18,108. H. H. Lake. London. Improvements in casings for electric cut-outs (S. Bergman, United States). December 11, 1888.

18,116. A. B. Atkinson and H. Metcalf. Brighton. Improvements in electrical primary batteries. December 12, 1888.

18,137. W. Hartnell. Leeds. Improvements in simple and compound switches for electrical currents. December 12, 1888.

18,154. P. C. Wood. London. Improvements in and relating to door-locks and fastenings, consisting of an electro-magnetic lock connected with an alarum. December 12, 1888.

18,187. M. Immisch. London. Improvements in electric generators and in electro motors. December 13, 1888.

18,220. E. Batault. London. Improvements in electricity meters or columb meters (date applied for under section 103 of the Patents, &c., Act, 1883, July 28, 1888, being date of application in Belgium). December 13, 1888.

18,233. H. A. Taylor. London. Improvements relating to duplex electric telegraphs. December 13, 1888.

18,242. R. H. Courtenay. London. Improvements in electrical apparatus for the transmission of sound. December 13, 1888.

18,245. C. Coerper. London. Improvements in electric lamps or lighting apparatus. December 14, 1888.

18,255. N. G. Thompson. London. Improvements in electric alarms. December 14, 1888.

18,262. P. W. Sothmann and C. O. H. Kroll. London. An electric speed regulator for marine engines. December 14, 1888.

18,278. G. Wilkinson and T. W. Holmes. London. Improvements in laying electrical conductors underground. December 14, 1888.

18,306. A. Serraillier, J. T. Armstrong, and The Automatic Electric Supply Company (Limited). London. Improvements in the construction of apparatus for communicating currents of electricity to persons on the introduction of specified coins or checks. December 14 1888.

COMPLETE SPECIFICATIONS ACCEPTED

NOTE.—*All persons interested in opposing the grant of a patent on any one of the undermentioned applications may, at any time within two months from the date in italics, give notice at the Patent Office in the prescribed form of such opposition.*

December 15, 1888.

242. J. H. Davies. London. Improvements in electrical measuring instruments. January 6, 1888.

366. C. D. Abel. London. Improvements in electric arc lamps (the firm of Siemens and Halske, Germany). January 9, 1888.

1,525. L. E. Solignac. London. Improvements relating to the distribution of electricity. February 1, 1888.

2,449. O. Allen. London. Improvements in systems of and mechanism for electric railways. February 18, 1888.

11,514. T. R. Douse. London. Electrically controlled apparatus for checking, extinguishing, and preventing the spread of fire, and for simultaneously giving the alarm. August 9, 1888.

13,529. A. Reckenzaun. London. Improvements in electric meters. September 19, 1888.

14,979. R. R. Hutchinson. London. Improved electrical brake and apparatus for automatically actuating same. October 18, 1888.

15,865. C. J. Munier. London. Improvements in multiple printing telegraph apparatus. November 2, 1888.

PATENTS SEALED.

December 14, 1888.

13,326. J. Douglas and H. Abbott. London. Improvements in machinery or apparatus for producing and administering electric shocks and currents. October 1, 1887.

15,063. P. Skrivanow. Paris. Improvements in galvanic batteries. November 4, 1887.

16,623. W. T. Goolden and L. B. Atkinson. London. Improvements in dynamo electric generators and motors. December 2, 1887.

17,089. M. Immisch. London. Improvements in the construction of the cores of the armatures of electro-motors and dynamo machines. December 12, 1887.

5,390. J. Sherrin and J. V. Sherrin. Ramsgate. Improvements in velocipedes and other vehicles propelled by electricity. April 11, 1888.

7,463. M. Kotyra. Cardiff. Improved commutator for magneto or dynamo-electric generators. May 19, 1888.

12,395. A. J. Boult. London. Improvements in electro-therapeutic belts (H. P. Pratt, United States). August 28, 1888.

12,706. W. P. Thompson. Liverpool. Improvements in storage battery plates (C. D. P. Gibson, United States). September 3, 1888.

12,761. A. G. Waterhouse. United States. Improvements in dynamo-electric machines. September 4, 1888.

SPECIFICATIONS PUBLISHED.

4,673A, 1888. Justice, P. M. (Heisler). Switch, &c., for incandescent electric lamps. (Price 8d.)

12,063, 1888. Boult, A. J. (McLaughlin). Electrical type writers, &c. (Price 11d.)

12,064, 1888. Boult, A. J. (McLaughlin). Electrical type writers, &c. (Price 11d.)

12,065, 1888. Boult, A. J. (McLaughlin). Electrical type writers, &c. (Price 8d.)

12,453, Thompson, W. P. (Diehl). Hardening and tempering by electricity. (Price 8d.)

14,492, 1888. Sutherland, J. B. Electrical signalling, &c. (Price 8d.)

12,676, 1887. Goolden, W. T., and Atkinson, L. B. Dynamo-electric generators, &c. (Price 8d.)

17,231, 1887. Edmunds, H. Distributing electricity. (Price 8d.)

718, 1888. Guitton, E. (Sappey.) Self-acting electric batteries. (Price 11d.)

981, 1888. Spratt, C. Electric "call" signal apparatus. (Price 11d.)

984, 1888. Burleigh, W. F. Controlling railway signal levers by electricity. (Price 8d.)

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13,598, 1888. HUTCHINSON, R. R. Electric motors. (Price 8d.)
14,980, 1888. HUTCHINSON, R. R. Operating capstans, &c., by electricity. (Price 6d.)
14,981, 1888. HUTCHINSON, R. R. Actuating printing machinery by an electric current, &c. (Price 8d.)
14,985, 1888. HUTCHINSON, R. R. Utilising a current of electricity for pile-driving machinery, &c. (Price 8d.)
14,986, 1888. HUTCHINSON, R. R. Applying electricity as a motive power to cranes, shear legs, &c. (Price 6d.)
14,988, 1888. HUTCHINSON, R. R. Brewing, &c., "mashers" and "mixers," and applying electricity as a motive power for same. (Price 8d.)
14,989, 1888. HUTCHINSON, R. R. Steering apparatus for ships and utilising electricity as a motive power for same. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The Western Counties Telephone Company.

An extraordinary meeting of the shareholders of the Western Counties and South Wales Telephone Company was held at the Grand Hotel, Mr. Charles Nash presiding, on the 9th inst.

The SECRETARY (Mr. H. F. Lewis) read the notice convening the meeting, and the subjoined resolution, which was the cause of the gathering:—

"That Clause or Article 71 of the Articles of Association shall stand as in the original articles, subject only to such variation that in place of the original sub-section (a) the following provision shall be inserted, viz.:—(a) They may borrow any sum or sums of money on such security and terms as to interest or otherwise as they may deem fit, and may secure the same by mortgage or other debentures, or by bonds or other securities, or by any mortgages or charges of or upon the whole or any part of any property, funds, assets, or effects of the company, including its uncalled capital; but so that not more than £50,000 be owing at any time without the consent of a general meeting, and provided that not more than £30,000 shall be borrowed without the consent of the United Telephone Company (Limited), and no borrowed money shall, without the like consent, carry interest at a higher rate than 6 per cent. per annum."

The CHAIRMAN said they would understand from what had been read that the chief object of the gathering was the raising of additional capital. Of the £80,000 which they had power to raise it was only proposed to offer £30,000, and as this would be at the rate of 5, instead of 6 per cent., there would be some saving in interest to the Company. He had to congratulate them upon the steady progress which the system was making. This applied to all their centres. In Bristol, including private line-renters, they had more than 500 subscribers, Plymouth 300, Portsmouth and Bournemouth 200, whilst Torquay, Cardiff, and Swansea, were fast drawing up to 200 each. The Company had recently opened an exchange at Cheltenham, and the prospects there were fairly encouraging. The trunk system had extended, and the contemplated extension between Bristol and Birmingham was in a forward state, and they were looking forward to Bristol being connected with London before the end of the year. That the public appreciated the use of the trunk system was shown by the fact that in 1887 the number of messages spoken was 6,945, and in 1888 14,675—more than double. It was intended to give subscribers the free use of the depôts for local calls, which he thought would have the effect of still further popularising the system. The recent letter in the *Lancet*, written by Mr. A. H. Twining, showing the undoubted accommodation which the telephone was to rural doctors, would doubtless lead many country practitioners to connect their residences with the system. Concluding, the Chairman said although the Act gave them power to raise capital at 6 per cent., yet it was only intended to pay 5 per cent. on the debentures now to be issued. There was nothing further for him to add than to congratulate the shareholders upon the fairly satisfactory condition of the Company.

Mr. MARK WHITWILL seconded the resolution, and said the reason more money was wanted was that the company was compelled to extend its business.

Mr. RICHARD CORY (Cardiff) cordially supported the resolution, and alluded to the immense benefit the telephone was to the coal merchants and others at Cardiff and South Wales, as it enabled them to communicate directly with the collieries. He should not be surprised if the number of messages on the trunk system quadrupled themselves during the ensuing year. There was a great future for the telephone, he felt certain, in South Wales, and this applied doubtless to the other districts in which the Company worked.

The proposal was unanimously adopted, but it will have to be confirmed at a second meeting as a special resolution.

The Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 31st December, 1888, to be presented to the twenty-third ordinary general meeting of the company, to be held at Winchester House, Old Broad Street, London, E.C., on Friday, the 25th inst., at 2 p.m.:—

2. The Revenue for the half-year (still subject to revision on settlement with the French Company), after deducting out-payments, amounted to £34,188. 0s. 0d. against £23,002. 17s. 6d. (after similar deductions) for the corresponding period of 1887, being a difference of £11,185. 2s. 6d. in favour of the half-year under review, owing to the increased tariff in force since the 1st September last.

3. The working and other expenses for the same period, including income tax, amounted to £16,475. 6s. 9d., leaving a balance of £17,712. 13s. 3d. as the net profit of the half-year. For the corresponding half-year of 1887 the working expenses and other payments amounted to £15,864. 18s. 0d.

4. Interim dividends of 2s. per share for the quarter ended 30th September, 1888 (paid 24th October, 1888), and of 3s. 6d. per share for the quarter ended 31st December, 1888 (payable 26th January, 1889), together amounting to £16,695. 5s., have been declared.

5. It having been demonstrated by an exhaustive trial over a period of more than two years that a 6d. tariff did not yield an appreciable profit, the tariff was on the 1st September last raised to 1s. per word, by agreement between the associated companies (including the French Company) and the Commercial Cable Company. The result of the altered rates so far has been to reduce the volume of the traffic, but the receipts have been fairly augmented.

6. The repairs in the deep sea portion of the main cable, to which reference was made in the fifth paragraph of the last report, were completed on the 8th August last, thus placing the cable in efficient working order throughout. The total cost of the repairs, including 218 knots of new cable used, amounting to £58,814. 0s. 1d., has been charged to the reserve fund account. The cost of removing the cables and station from Torbay to Halifax (N.S.) and diverting the cable from Brown's Bank, amounting to £23,638. 10s. 5d., has also been debited to the same account.

7. A joint station (worked by this company) has been established by the Associated Companies at Boston, Massachusetts.

8. Arrangements have been made enabling the company to dispense with the Chester station, which was accordingly closed in December last, whereby a saving will be effected. This station was used solely for transmitting purposes.

9. The appeal of the Cie. Française du Télégraphe de Paris à New York, mentioned in the last report, is still pending.

10. Mr. T. Finnis has been appointed secretary, and Mr. P. Oscar L. Moll traffic manager of the Company, in the place of Mr. J. W. Fuller, who held both offices.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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Eastern Telegraph Company (Limited).

The following is the report of the Directors for the half year ended 30th September, 1888, to be presented to the thirty-third half-yearly ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, London, E.C., on Thursday, the 24th inst., at one o'clock :—

2. The revenue for the period amounted to £310,104. 15s. 8d., from which are deducted £83,332. 3s. 0d. for the ordinary expenses and £43,075. 8s. 8d. for expenditure relating to repairs and renewals of cables, &c., during the half year. After providing £4,226. 15s. 7d. for income-tax, there remains a balance of £179,470. 8s. 5d., to which is added £884. 8s. 9d. brought from the preceding half year, making a total available balance of £180,354. 17s. 2d.

3. From this balance there have been paid—

	£	s.	d.
Interest on Debentures and Debenture Stock	£28,264	12	4
Dividend on Preference Shares	20,474	3	10
Two interim dividends of 1¼ per cent. each on Ordinary Shares	95,000	0	0
	£143,738	16	2

Leaving a balance of £36,616. 1s., which is carried forward to the next account.

4. The revenue includes £25,791. 15s. 11d. dividend for the half year upon the Company's shares in the Eastern and South African, the Black Sea, and the Direct Spanish Telegraph Companies. The cables of these companies are in good working order.

5. Details are given in Abstract C of the accounts of the repairs and renewals of the cables, the several sections of which are now in good working order, with the exception of the Aden-Bombay original cable, which is under repair.

6. The Directors have entered into a new convention with the French Government for the special wire through France, in connection with the Company's cables at Marseilles, and the prolonged negotiations on this subject are thus satisfactorily concluded.

7. In accordance with the special resolutions passed at the extraordinary general meeting held on the 22nd November last the 20,000 new ordinary shares have been issued and taken up by the shareholders at £12 per share.

8. The new cables for the West Coast Lines of the Eastern and South African Company, which are to be worked by this Company, are in course of manufacture by the Telegraph Construction and Maintenance Company, and the India Rubber, Gutta Percha and Telegraph Works Company, and will be laid, according to contract, during the spring.

9. The Directors regret to announce the death, in August last, of Lord Alfred Paget. The vacancy thus occasioned on the Board has been filled up by the election of Sir Albert J. Leppoc Cappel, K.C.I.E., late Director-General of Telegraphs in India.

10. In accordance with the Articles of Association, two of the Directors, Lord Sackville A. Cecil and Sir Albert J. Leppoc Cappel, retire by rotation at this meeting, and being eligible offer themselves for re-election.

11. The auditor, Mr. Henry Dever, retires and offers himself for re-election. The auditors, Messrs. Quilter, Welton and Co, also retire, and offer themselves for re-election under their new style of Welton, Jones and Co., adopted since the death of Mr. Quilter.

THE EQUITABLE TELEPHONE ASSOCIATION (LIMITED).

The following circular letter has been issued to their customers by the Equitable Telephone Association :—

75, Queen Victoria-street, London, E.C.,
27th December, 1888.

SIR : You are, we believe, aware that the United Telephone Company, some months ago, commenced an action against the Association for infringement of their telephone patents, and that they obtained an interim injunction pending the trial of the action.

The shareholders of the Association, in general meeting, having decided not to provide further funds to continue the litigation, the Association is consequently unable to further contest the question of infringement raised by the United Telephone Company, and, having regard to all the circumstances of the case, have found no course open to them but to submit to a perpetual injunction on the usual terms. At the same time, the United Telephone Company have undertaken not to make any claim for damages against persons who have purchased or have been supplied with telephone instruments by the Association for their own use, provided they deliver up such instruments intact to the United Company, of Oxford-court, Cannon-street, E.C., by the 4th January.

The Equitable Telephone Association in these circumstances regret that they can only suggest that customers of the Association shall give up their instruments to the United Company accordingly, and by so doing avoid possible liability.

The Equitable Telephone Association having no further funds, and the injunction practically putting an end to their business, will now be obliged to wind up its affairs.

For the Equitable Telephone Association (Limited).

CHAS. J. WARDEN, Secretary.

NEW COMPANIES REGISTERED.

NEWCASTLE-UPON-TYNE ELECTRIC SUPPLY COMPANY (LIMITED).—This company was registered on the 8th inst., with a capital of £50,000 in £5 shares, to supply electricity for lighting and other purposes in Newcastle-on-Tyne, and elsewhere in the counties of Northumberland and Durham. The number of directors is not to be less than 3, nor more than 9 ; the subscribers are to appoint the first ; qualification £100 in shares or stock ; the company in general meeting will determine remuneration.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this company for the week ended January 11th amounted to £5,247.

DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The board of this company have resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income-tax, being at the rate of of 3½ per cent. per annum, for the quarter ended December, 1888, such dividend to be payable on and after the 26th inst.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company notifies that the interest, due on February 1 proximo, on their Six per Cent. Debentures will be paid on and after that date at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

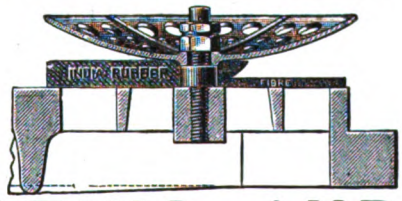
GLOBE TELEGRAPH AND TRUST COMPANY.—The directors of this company have declared a dividend for the past quarter of 3s. on the preference and 1s. 3d. on the ordinary shares.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this company for the week ended January 11, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,248.

REMOVAL.—Mr. A. A. Campbell Swinton has opened new offices at 66, Victoria-street, Westminster, where all communications should now be addressed to him.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.
"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Jan. 16, 18-9.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Jan. 16, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	7/6	Anglo-American	51 52	2 12 4	Jan., Apr., July, Oct.	51¼	48
2,614,820	Stock	15/0	Do. Preferred	85 86	3 3 11	,, ,,	85⅝	80½
2,614,820	Stock	5/0	Do. Deferred	18 18½	...	February	18½	16½
130,000	£10	3/0	Brazilian Submarine	13¼ 13½	5 3 8	Mar., June, Oct., Dec.	13 3/16	13⅜
112,900	£100	5%	Do. 5 per Cent. Bonds	101 104	4 16 2	January and July	104	102⅝
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14 14½	5 17 3	February and August	14½	...
6,000	10	10/0	Do. Preference 10%	18 19	5 5 3	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3¾ 4¼	3 15 4	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States xd	10 10¼	3 18 1	Jan., Apr., July, Oct.	10 5/16	9 1/16
380,000	10	2/6	Eastern xd	12⅜ 12⅝	4 15 1	,, ,,	12¾	12 7/16
70,000	10	3/0	Do. 6 per Cent. Preference xd	14⅞ 15¼	3 18 8	,, ,,	15	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	105 107	3 14 9	May and November.	107	106¼
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	...	...
250,000	10	2/6	Eastern Extension xd	12⅝ 12⅞	5 1 0	Jan., Apr., July, Oct	12⅞	12 1/16
3 0,000	100	6%	Do. 6 per Cent. Debentures, 1891	104 106	5 13 2	February & August	...	...
47 ,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	101 104	4 16 2	January and July	102	...
179,177	10	1/3	Globe Telegraph and Trust	7 7½	5 4 11	Jan., Apr., July, Oct.	7⅛	7
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14⅝	14⅜
150,000	10	5/0	Great Northern	14½ 15	3 6 8	Jan., July, and April	14¾	14 1/16
17,000	25	2/6	Indo-European	38 40	6 5 0	April and October	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
15,609	10	3/0	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98	...
30,000	10	6/0	West Coast of America xd	8¾ 9¼	6 9 9	January and July	9⅛	9
150,000	100	8%	Do. Debentures 8%	117 121	6 12 3	June and December	...	...
88,321	10	nil.	West India and Panama	1⅝ 1⅞	...	...	1¾	...
34,563	10	12/0*	Do. 1st Preference 6%	11½ 11¾	5 2 2	April and October	...	...
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	12	...
45,181	15	6/0	Western Brazilian	12⅜ 12⅝	5 18 8	March & September	13 3/16	13¼
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅝ ¾	...	Yearly	1⅛	...
220,000	£1	2½%	Oriental (11s. paid)	5/16 7/16	3 2 11	...	...	...
80,000	5	5/0	United	14½ 14⅝	5 5 3	June and December	14⅝	14 5/16
55,000	5	3/0	United River Plate xd	5⅝ 5⅞	...	January and July	5¾	5 7/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3¾ 4¼	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4¾ 5¼	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	2⅝	...
312,000	½	5% '86	Maxim-Weston	1/16 1/8	...	February	...	...
			MISCELLANEOUS.					
37,350	12	12/0	Telegraph Construction and Maintenance	41½ 42½	5 16 3	March and July	42	41½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	19 20	5 0 0	February & August	19⅞	19⅝

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 558.—Vol. XXII. FRIDAY, JANUARY 25, 1889. Price Sixpence.

NOTES.

We this week have the pleasure of presenting to the subscribers of *The Electrician* a steel plate portrait of the new President of the Institution of Electrical Engineers, Sir William Thomson, F.R.S., &c., &c. The portrait has been engraved from a photograph taken by Elliott and Fry, of Baker-street, by means of the electric light.

We understand that a committee of the Council of the Institution of Electrical Engineers has been formed to consider, in conjunction with the Board of Trade, the regulations for controlling overhead wires. This committee has been appointed at the request of the Board of Trade.

Prof. Forbes' interesting Paper on "Electricity Meters," read before the Society of Arts on Wednesday evening, derives additional importance from the fact of its being really the first occasion on which a connected view of the subject has been presented. Prof. Forbes laid down no less than fifteen points as essential to the perfection of a meter, and he described in detail some six or eight instruments which come within measurable distance of that standard. We used to be told that the proper thing to do was to measure the watts, and that coulomb-meters were to be considered merely as makeshifts; Prof. Forbes, however, maintains that it is better to integrate the current only, and trust to the inspectors to look after the volts. Prof. Ayrton objected to this strongly, chiefly on the ground that a very small variation of voltage—a variation within the allowed limits—makes so great a difference in the light actually supplied. Moreover, if you are charged by coulomb-meter, and you turn on additional lamps because the volts have fallen off, you have to pay for the additional current. To this Prof. Forbes retorted that if you are charged by erg-meter, and the Company chooses to overrun your lamps, not only have you to pay for more light than you want, but you have also the pleasure of buying an additional number of lamps per annum. However, the public may take it for granted that these little difficulties are not really so formidable as they appear, and in comparison with the iniquities of gas-meters the electricity meter may almost be pronounced immaculate. Next week we hope to print the Paper in full, together with a report of the debate.

Prof. Jamieson has also done good service in bringing the subject of the Insulation Resistances of Installations before the Institution of Electrical Engineers. It is to be feared that the practice of testing insulation resistance has been very much neglected in the electric-lighting industry; but Prof. Jamieson's hints for the use of ordinary ammeters and voltmeters for this purpose will, no doubt, be of assistance to many people. It is very satisfactory to find that Prof. Jamieson's experience leads him to believe that there is no practical difficulty in an average case in attaining an even higher standard of insulation than that demanded by the Installation Rules of the Institution.

The Council of the Institution of Electrical Engineers, after mature deliberation, has arrived at the conclusion that the welfare and the dignity of the Institution will be best consulted by the exclusion of newspaper reporters from its debates. The question is one of greater importance to the Institution than to the technical press, and for our own part we do not pretend to have given it that thorough consideration which would enable us to arrive at any very decided opinion. In our issue of December 11th we committed ourselves to the observation that much might be said on both sides of the question. It is, for instance, clear on the one hand that any tendency on the part of members to abuse the facilities offered by the Institution in order to advance their individual schemes with the outside public should be strongly discountenanced. On the other hand, we must confess that we were not previously alive to the fact that such a state of things existed to anything like a serious extent. It is also obvious, from the same point of view, that the non-reporting of the debates entails additional responsibility upon the Council in respect of the Papers accepted, and it would perhaps have been a more consistent course had their publication likewise been discontinued. Any movement which conduces to the best interests of the electrical engineering profession must necessarily command our cordial assent, and in these matters the Council of the Institution ought certainly to be the best judges—only we would have them bear in mind that the Institution exists for the sake of electrical engineering, and not electrical engineering for the sake of the Institution.

On most of the points raised in Mr. Shelford Bidwell's letter, which we printed last week, we are inclined to agree with him. But after giving the matter some further consideration we still think he has left the main point in dispute pretty much where it was. At bottom the demand for an open "house list" of nominations arose out of the objection, which most men entertain, to taking part in an empty formality, especially when that formality consists in registering a foregone

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conclusion on which they have not been consulted. There are difficulties, no doubt, attending an opposite course; but they are probably not insurmountable; and to overcome administrative difficulties is part of the business of every Council. Mr. BIDWELL does not help them much. In one portion of his letter, if we understand him rightly, he states that when the ballot paper reaches him with more names than have to be elected he flings it into the waste paper basket, because in his judgment, the Council ought to have saved him the trouble of selection. We should like to ask him what he did with the paper when it nominated those only who were to be elected? Did he return it? If so, with what object? The gist of the whole matter is contained in this last question; and we should be glad to hear from anyone who has a rational answer to give to it.

MR. CAMPBELL-SWINTON gives in this issue an interesting account of the investigation carried out by Mr. W. BROWN (of the Central Telegraph Office) on the cause of the interference on the Equitable Telephone Company's wire in Knightrider-street. After Mr. PREECE'S more extended experiments upon the same subject we do not, however, know that we are called upon to express any great degree of surprise that the telephone should prove sensitive to disturbances originating at a distance of 100 yards. There is, however, one distinguishing feature in this case which deserves greater attention than it has received, and which, moreover, affords a beautiful illustration of Dr. FLEMING'S "Theory of Screening," which we published last week (see *The Electrician*, January 18, p. 300). We refer to the fact that the wire which influenced the telephone was enclosed in an iron pipe.

IN our issue of June 22nd, 1888, we recorded the result of a test case which had been brought before the United States Circuit Court with the object of determining the validity of a whole batch of the Edison patents, including a sweeping claim to the use of incandescent lamps in multiple arc, and also several of the most important patents for the manufacture of lamps. These claims were all open to the objection that the life of the analogous patents in one or more foreign countries had already terminated, and it was maintained that in accordance with the United States Patent Law the American patents had lapsed at the same moment. This interpretation was upheld by the lower Court, but we learn from a telegram in the *Standard* that this decision has been reversed, on the ground that the United States patent extends "to any period to which the foreign patent may be extended, and that irrespective of whether the privilege of the extension abroad is exercised or not." This decision would appear to be of the utmost importance to the electric lighting industry in the States, and we await with interest the arrival of definite information from our New York correspondent.

SINCE writing the above we have received the following cablegram from our New York Correspondent :—

"The United States Supreme Court, Washington, rendered on Monday last, in the case of the "Bate Refrigerating Company *v.* Hamond and Co.," a very important decision, bearing directly on electric lighting interests. The decision was to the effect that, contrary to opinion of Circuit Court below, an American patent was not limited in its duration by the shorter term of the foreign patent, but should run its full course, unaffected by original term of patents taken out abroad and afterwards extended. This affects favourably about a dozen of Edison's leading incandescent lamp patents, which had been taken out abroad originally for shortest term permitted. The Bate case, in the Supreme Court, has been carried on with help of the Edison counsel. The way is now cleared for direct adjudication on merits of patents, and it is said that suits proper will be actively taken up at this juncture. It is interesting to note that the parent Westinghouse and United States Electric Lighting Companies have just entered into working arrangement on both a patent and manufacturing basis. It is a strong combination."

WE understand that Captain CARDEW, R.E., has been appointed Technical Adviser to the Board of Trade in connection with the Electric Lighting Acts. We may add that the Board of Trade has adopted the recommendation of the London Chamber of Commerce in the matter of the unit of electrical supply, which is now defined as the equivalent of 10,000 amperes flowing under an E.M.F. of one volt during one hour.

WE have the highest authority for the statement that it is impossible for any man to serve two masters, but it is the unhappy fate of the Electricity Supply Companies to attempt the still more hopelessly impossible task of serving not merely two, but a whole multitude of masters. First and foremost, they have to please the public, and this is probably the easiest part of their duty. Then there is the "local authority" to be considered, which—not to put too fine a point upon it—is apt sometimes to be pig-headed. Next there is the all-powerful and irresponsible authority embodied in the redoubtable Mr. HEAPHY, Inspector-General of Fire Offices. Lastly, but not least, the edicts of the Board of Trade, representing Imperial power, have to be received with due submission. Now, supposing—we only say supposing—that between these two last-named and most potent masters an irreconcilable conflict of opinion should arise, what on earth are the companies to do then, poor things? Supposing, for instance—and our readers will not fail to note that we only say supposing—the Board of Trade in the performance of their important duties were to become convinced that the public safety demanded the use of a certain specified device to avoid the danger of the primary current entering the secondary circuit of a transformer, and supposing that the Fire Offices arrived at a diametrically opposite conclusion, what then would be the position of the Electricity Supply Companies, and what would be the position of the electric light? These are questions which we confess our total inability to answer, but (though we only said "supposing") it is, perhaps, of some consequence to look them in the face.

WE are informed that the contract for the construction of the Southwark Bridge station of the Metropolitan Electric Supply Company has been awarded to Messrs. JOHNSON and

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PHILLIPS, who will employ the alternating-current system of Mr. GISBERT KAPP. The plant is to be capable of supplying 500,000 watts at the terminals of the transformers, and will consist of five 120 kilo-watt dynamos, belted direct to separate engines. The boilers will be designed to supply 1,100 horse-power. The tender includes the supply and fitting of every portion of the plant, including engines and boilers, but the steam plant has not yet been finally selected. We may add that the specification requires an alternating current of 16,000 reversals per minute. It is expected that the work will be completed by the end of July.

WE have already made some reference to the Cleveland electric heating hoax, but hitherto we had supposed it to belong to the harmless type of which Cabbage Leaf Filaments recently furnished a successful specimen. (This latter story, by-the-bye, has made its way into *Hardwicke's Science Monthly* as the account of a genuine process.) We learn, however, from the *Progressive Age*, of New York, whose editor evidently implicitly believes in Mr. BREVOORT'S good faith, that a company will shortly be established to work the "new process for the electrical generation of heat." This announcement at once places it in the same category as the Electric Sugar frauds, and it may therefore be as well to denounce the thing as a swindle without more ado.

THE story first made its appearance in the columns of the *Cleveland Press*, and ran to the effect that a mechanic who lived in a back street of that city was on the point of realising an invention no less marvellous than the "generation of heat from electricity."

"For years," he is reported to have said, "I studied and experimented in vain. I commenced on the electro-thermic battery, reasoning that if heat generated the electricity, by working backward heat could be made by electricity. For a long time I clung to this, but had finally to abandon it as practically impossible. Various other theories were tried and many weary hours spent in study when I should have been resting from my day's work. Some of my experiments produced heat, but not in sufficient quantities to be of any benefit." But at length a new light dawned. "The first thing necessary was to form a substance on which the electricity could act. The result of this effort was a composition called carbodium and resembling carbon, of which it is largely composed. By adding certain acids it can be melted and moulded in any form desirable—in masses to put in grates, shaped like radiators, flat, and placed under registers or whatever way wanted. To opposite sides of a piece of this composition wires were connected, and to the opposite ends of one of these an ordinary electric button was attached, on pressing which heat was at once generated in the compositon."

There is a good deal more of this sort of thing, including a pathetic account of the early struggles of the "inventor," and we are told that the current sufficient for one incandescent lamp "will heat with ease almost any number of rooms." The apparatus, which is now on exhibition in Cleveland, is to be rented to subscribers, and will not be sold outright. It is quite unnecessary to say another word to convince the technical reader that the thing is a fraud; but for the sake of the general public we may state that the "generation of heat from electricity" was one of the very earliest discoveries of electricar science, that as to its practical application there is neithel any difficulty nor any mystery about it, though as a general rule it does not pay to carry out. As for "carbodium," nothing could well be more absurd than the addition of acids to carbon to make a fusible compound.

Meiringen.—The little town of Meiringen (Switzerland) will shortly be entirely lighted by electricity.

Metz—The German Government has decided to provide all the forts round Metz with fixed and portable projectors.

Morecambe.—As will be seen by our advertisement columns, the Morecambe Tramways Company invite tenders for working their line by electricity.

The E.P.S. Calendar.—The Electrical Power Storage Company has issued a most useful office requisite in the shape of a combined calendar, diary, address book, and blotting pad.

Rome.—The municipal authorities of Rome have recently appointed a committee to study the question of lighting the entire city by electricity upon the lines laid down by the Anglo-Roman Gas Company and others.

Leeds Mechanics' Institute.—The new wing of the Leeds Mechanics' Institute, which has been built at a total cost of £7,000, was opened on Tuesday, the 15th, by Sir James Kitson, Bart. The new wing comprises the School of Science and Technology and Boys' Modern School.

Mandalay Tramways.—The Municipality of Mandalay have granted a concession to Mr. George E. L. Dawson to construct certain steam or electric tramways in that city. No agreement will, however, be entered into until all the terms thereof have been approved by the committee.

Hooper's Compound.—A piece of an Indo-European cable covered with Hooper's composition, which was laid down in 1868, was recently examined. Though immersed for twenty years it seemed to be in nearly as good a state as when new, the resistance of the insulation being 4,000 megohms per knot at the ordinary temperature.

The Institute of Medical Electricity.—The Institute of Medical Electricity has recently received pleasing testimony to the fact that it is doing good work, in the shape of a present of ten guineas worth of books for the reference library, which a patient has presented as a mark of his gratitude for benefits and attention received at the Institute.

West African Telegraph Company.—The *Gaceta de Madrid* contains a Royal decree from the Spanish Minister for the Colonies, authorising a contract between the Spanish Government and the West African Telegraph Company for the laying of submarine telegraph cables between the Island of Fernando Po and the African coast, and also with Prince's Island.

St. George's (Hanover-square) Vestry.—At a meeting of this Vestry, on Thursday, the 17th, a memorial was read from some ratepayers in New Bond-street, complaining of the annoyance caused by the works of the Grosvenor Electric Lighting Company at the rear of the Grosvenor Gallery. The memorial was referred to committee for consideration and report.

Electric Lighting at Manchester.—At a meeting of the Edison-Swan Company in Manchester, which is further reported in another column, it was resolved to open a central station in Piccadilly for the supply of 10,000 lights, at an average cost of 25s. each. It was stated that the initial expense would be £40,000, and £8,000 per annum would be required to keep the system in operation.

The Cox-Walker Swinton Magneto-Electric Bells.—Mr. A. A. Campbell Swinton, of 66, Victoria-street, S.W., has taken the supply of these instruments into his own hands. Large and powerful bells on this system for use on railways, in mines

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colleries, &c., are now being made in both tremulous and single-stroke varieties. It is expected that the absence of any battery will render these bells very popular for these purposes.

The Birmingham Electric Lighting Committee.—A meeting of the Sub-Electric Lighting Committee of the City Council was held at the Council House last week. Mr. George Hookham (Messrs. Chamberlain and Hookham) was present, and a discussion lasting upwards of two hours took place on the requirements of the Council with respect to the proposals of the firm named. No decision was arrived at, and the matter was again adjourned.

Holborn Board of Works.—At a meeting last week the Committee of Works reported that they had received applications from the London Electric Supply Corporation and the Metropolitan Electric Supply Company, for the assent of the Board to the company's application for Provisional Orders. The committee further reported that they had directed the clerk to convene a meeting for Monday, February 18th, to consider the applications of the two companies.

Newington Vestry.—At a meeting of this Vestry, on Wednesday last week, the Works and Sanitary Committee recommended—"That the application of the House-to-House Electric Light Supply Company (Limited) for the consent of the Vestry to enable them to apply to the Board of Trade for a Provisional Order be not entertained; but that no objection be offered to the draft Provisional Order lodged with the Board of Trade by the London Electric Supply Corporation, or any action taken to watch the progress of the order through Parliament." The recommendation was adopted.

Exhibition at York.—We have received an advanced copy of the prospectus of the Fine Art, Ecclesiastical, Educational, and Industrial Exhibition to be held at York from June to October next. A part of the cash receipts for admission will be handed to the County Hospital and to the City Dispensary, which, so we are informed, are much in need of pecuniary help. We notice that the grounds are to be "decorated and brilliantly illuminated with *gas* devices," electrical apparatus being relegated to the miscellaneous section amongst aerated waters, preserved food, and other "olla podrida."

The Paris Electric Meter Competition.—A correspondent writes: "For some time I have been looking for an announcement of the particulars of the Electric Meter Competition in Paris, and find a paragraph in your issue this week giving *some* information. Would you please give in your next the date of the competition, the place at which competitors are to enter their names, and such other items as may be useful to competitors." We shall make a point of publishing this information at the earliest possible moment, but up to the present no official announcement has been made beyond what we have already given.

Central Station Lighting in Moscow.—A correspondent writes us from Odessa as follows:—"The Moscow papers state that a few days ago there took place the inauguration of a central electric light station. It is a big edifice of 308 feet in length, 70 feet in breadth, and 160 feet in height. The front is lit by two arc lamps of 2,000 candle-power each. Over 26 miles of underground cables for lighting purposes are laid to the principal parts of the town, and 15,000 incandescent lamps can be supplied. At present there are only 100 trading-houses supplied with the electric light, to the amount of 2,500 16 candle-power incandescents No further particulars have reached here as yet."

Street's "Indian and Colonial Mercantile Directory."—We have received a copy of the new edition of the "Indian and Colonial Mercantile Directory." This work, which is published by Messrs. Street and Co., is of a very useful description. All particulars likely to be of use to commercial men, such as trade, population, steam communication, lists of the principal merchants, &c., are given for the chief trading towns in India, the Colonies, China, and Japan. Maps of all the principal countries referred to, and concise descriptions of each country and town are furnished. The information is well up to date, and this publication ought to prove of great assistance to all engaged in the colonial trade.

The City.—At a recent meeting of the City Commissioners of Sewers Mr. Bridgeman brought up a report of the Streets Committee on the subject of electric lighting, and submitted draft conditions with a view to advertising for tenders. The report was ordered to be printed and circulated, and its consideration adjourned. The Joint Finance and Streets Committee reported, relative to the Electric Lighting Provisional Orders, in respect of which notices have been served upon the Commission, and recommend that the Court do oppose the same for the purpose of obtaining a *locus standi*, that it be referred back to them to watch and report thereon from time to time as may be necessary, and the clerk be authorised, on behalf of the Commission, to sign the necessary objections to be submitted to the Board of Trade.

The Liverpool Electric Supply Company.—The Watch Committee have resolved, after considering a report of the city engineer on an application of the Liverpool Electric Supply Company for the consent of the Corporation to their applying for a Provisional Order, that the Town Clerk reply that, having regard to the short time which has elapsed since the grant of the license, the committee have not had sufficient opportunity of observing the working of the system to enable them to adequately consider the application, and they therefore cannot recommend the Council, as the local authority under the Electric Lighting Acts 1882 and 1888, to consent to the company making an application for a Provisional Order.—The Health Committee have approved of a report of the City Engineer on plans submitted by the above company showing the position in which they propose to lay mains in the streets.

Reading.—It will be remembered that some two or three months ago Messrs. Laing, Wharton and Down obtained the sanction of the Reading Town Council to erect some arc lights in the main thoroughfares. That the firm are confident of doing business in the town is shown by the fact that they are putting down a costly and permanent plant on a site on what is known as the "Island," which has been acquired by them. In the boiler-shed provision has been made for two 25-horse power boilers, one of which is already *in situ*. Twin Armington-Sims engines of 9 horse-power nominal have been laid down to drive the dynamos. The dynamos (also in duplicate) are of the Thomson-Houston type, and these are each capable of running twenty 1,200 candle-power arc lamps. Thomson-Houston lamps will be employed for indoor purposes, and Thomson-Rice lamps for outdoor use. It is said that many of the business firms in Reading contemplate adopting the light.

Barnet.—At the meeting of the Barnet Local Board on Tuesday in last week, Mr. James asked whether any reason had been given for the failure of the electric light on the previous Friday evening. The lamps, he explained, were not exactly out, but they were like "red bars of iron, giving no light." The surveyor, in reply to the chairman, said he was unable to give any information. He had no instructions from the Board; no lighting inspector had been appointed, and he did not wish to volunteer a report. The chairman said it had occurred to him that they ought to have someone who really understood the matter, and who could give an independent and authoritative opinion whether the lamps were up to 32-candle-power, as provided for in the contract. They had no means of settling it for themselves; and they wanted the opinion of an expert who could swear to what he stated. A long discussion ensued, and in the end it was agreed to appoint an expert to report upon the whole subject of the electric lighting of the district. Another breakdown occurred on Wednesday evening, the light not being available up to a late hour.

The Jubilee of Electroplating.—It is now a little more than half a century ago that Jacobi, the originator of the first attempts at electrical navigation, published his discovery of the art of electroplating. In October, 1838, at a meeting of the Académie Impériale des Sciences, Jacobi imparted the results of his investigations to his colleagues, and in December of the same year the great discovery was announced in the papers. The Société Impériale Technique, at the instance of its secre-

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tary, M. Sreznevsky, has decided to celebrate this important anniversary by an exhibition, which will open in the middle of next month, and which will be divided into the following sections: 1. The history of the discovery of electroplating, including several specimens of Jacobi's first attempts and his correspondence upon the subject with various scientific bodies. 2. The technology of electroplating, with examples of its application to electrometallurgy and chemical analysis. 3. The application of electroplating to the arts and to industry. The Société Impériale Technique will celebrate the event by a *séance*, at which the President, M. Chwolson, will give an address on the significance of Jacobi's discovery.

The Dundee Art Galleries and the Electric Light.—A meeting of the Building Committee of the Victoria Art Galleries, Dundee, was held last week for the purpose of considering a report as to the best means of lighting the new galleries and the whole Albert Institute with the electric light. The report was drawn up by Mr. W. A. Bryson. Treating the Albert Institute as a whole—museum, picture gallery, both libraries, and the new galleries—Mr. Bryson proposed a very complete scheme, embracing arc lamps for the larger galleries and halls, and incandescent lamps for the smaller rooms, the initial cost of which, including everything—engines, dynamos, wires, lamps, &c.—would amount to £2,800, the annual working expenses to £180, and the annual cost of plant, including depreciation, to £443, or altogether £623 per annum, all these, however, being very full estimates, more likely to be lessened than exceeded. It was stated that the cost of gas for a year for the whole Albert Institute, including the amount consumed in the new galleries during the three or four months of an annual exhibition, would be fully £300. After discussion the question was remitted to a special sub-committee to obtain skilled professional opinion and report to a future meeting.

St. James's Vestry.—At a meeting of this Vestry on Wednesday, 16th inst., assent was given to the introduction of the Metropolitan Electric Supply Company's Bill to authorise the company to supply electricity in the parishes of St. James's (Westminster) and St. Martin's-in-the-Fields, on the terms and conditions agreed to last year. It was decided to offer no opposition to the draft Provisional Order of the London Electric Supply Corporation, on condition of certain amendments being made in the same. The amendments proposed were of a stringent character, and included the company undertaking to satisfy the Board of Trade that they were in a position to carry out obligations before beginning operations; not to associate themselves with any other company without the consent of the Vestry; and to remove all overhead wires, supports, &c., on notices to that effect from the Vestry, under penalty; and that the plans for the generating station and proposed buildings should be submitted to and approved by the London County Council. The Lighting Committee recommended:—"That the Board of Trade be invited to specially consider the proposal of the London Electric Supply Corporation to take powers to lay trunk mains in the district without coming under any obligation to supply electricity therefrom in such district, and also the proposal of the Corporation to take powers to supply electricity to local authorities for the latter to retail to consumers." The recommendation was adopted.

Address to Sir John Pender by the Glasgow Telegraph Staff.—The following address, which was signed by a majority of the leading officers and a large portion of the telegraph staff in connection with the Glasgow Post Office was forwarded to Sir John Pender on Saturday last:—"Sir: We, the undersigned members of the Glasgow Postal Telegraph staff, consider your presence in our city a fitting opportunity for expressing to you our appreciation of your efforts and success in establishing and extending telegraph communication all over the world. Thereby a great and valuable outlet is afforded for the employment of telegraphists, also mechanics and other workmen—an outlet which to telegraphists especially has been of the greatest value. In consequence of the liberal manner in which telegraphists in the employment of the companies are treated clerks are continually being induced to transfer their services from the Post Office to the service of the companies, and thereby the congestion of promotion in the Post Office is to some extent relieved. The considerations are to some degree sectional and local, and while the beneficial results of your enterprise have not been confined to us or to any class, but have extended to the whole commercial and industrial interests of Great Britain, we desire to place on record your generosity to your servants as a matter of our immediate and personal knowledge, and as a simple testimony of your symyathy with the workers of the world."

Chelsea.—The Electric Light Committee of the Chelsea Vestry reported at their last meeting that they had considered the copy of a deposited map and advertisement of application for Provisional Order by the London Electric Supply Corporation, Limited; also the letter from Messrs. Deacon, Gibson and Medcalf, on behalf of the London Electric Supply Corporation, Limited, notifying that they have deposited at the Board of Trade the draft of the Provisional Order for which they are making application, and enclosing a copy of the same; also asking for the Vestry's assent to the granting of the Provisional Order, and stating that they will be happy to afford all such further information as may be desired, and that they will, at the commencement of February, have to report to the Board of Trade whether the Vestry assent to the application. The Committee recommended that the Vestry do dissent from the granting of the proposed Provisional Order. The report was adopted. The Committee also reported that they had considered the memorial, bearing 432 signatures, presented to the Vestry on the 18th ult., praying for the removal of overhead wires, wherever the Vestry has jurisdiction, and recommended that the Vestry inform the memoralists that the jurisdiction of the Vestry in the matter of overhead wires is limited in extent, difficult of application, and doubtful in its effects, and that the Vestry are not prepared at present to initiate litigation against the owners of overhead wires. The report was adopted.

Electric Lighting at Portsmouth Dockyard.—We make the following extract from a leading article in the *United Service Gazette* of January 19th:—"Electric lighting has made, and is making, great strides at Portsmouth Dockyard. Mr. Lane, the electrician, commenced the work in the early days of naval search lights with a man and a boy. Now the electrical shop employs ninety-six hands, the greater number of whom are fitters, and within the next three months it is expected that this number will be increased to 250 hands, as the department is about to undertake the manufacture of the electrical apparatus fitted in Her Majesty's ships to a far greater extent than it has done in the past. Electricity has, no doubt, a great future before it, and it is satisfactory to learn that the Admiralty are beginning to move with the times with regard to this important branch of science. Electricity, for lighting purposes, is invaluable when ships are in course of construction and of being fitted. Under the ships' bottoms and in the interior of the ships, especially in the double bottoms and the other lower depths, the work has been expedited and improved, and inspection has been rendered far more speedy and much more effectual by the use of the incandescent light. A man can take a coil of wire and a 16-candle power light, and with it light up the darkest corner of the ship as it could not have been lit with the old system of matches and candles, which did little more than make darkness visible, to say nothing of the danger of fire; while the "stink-pots," which of old were supposed to light under the bottoms of ships were simply abominations. The difference between muddling along with shipbuilding work in semi-darkness and working under the brilliant illumination of electricity is so vast that officers and men are apt to wonder how they managed before they got the electric light. With regard to search lights, all the electricians have to do is to provide them. Their utility in action—that is, when they should be used and when they should not be used—still, we venture to think, requires great consideration and much experiment on the part of executive naval officers. The legitimate use is, no doubt, to show up advancing torpedo boats, and thus enable the quick-firing guns to play upon them; but, on the other hand, when within range of an enemy's artillery, the fact of using search-lights shows your position very accurately to their gunners.

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SIR WILLIAM THOMSON.

We publish this week a portrait of Sir William Thomson, recently (and for the second time) elected President of the Institution of Electrical-Engineers.

Sir William Thomson, though of Scotch descent, is an Irishman by birth. He was born in Belfast in June, 1824. For several generations his family had occupied a farm near Ballynahinch, in the County of Down; but his father, Dr. James Thomson, a very remarkable man and a born mathematician, managed to secure for himself an education at Glasgow University (travelling was not so easy in those days as it is now, and colleges were not so plentiful), and subsequently he became Professor of Mathematics at the Royal Belfast Academical Institution, and at a later date in the University of Glasgow itself. It was while Dr. James Thomson was Professor in Belfast that William Thomson was born, and he was eight years of age when his father removed to the old College in the High-street, Glasgow.

The children of Dr. James Thomson were educated by himself so long as they were children; and they seem to have early imbibed a taste for learning of every kind and much sound knowledge of the most diversified nature. At a very early age William Thomson and his elder brother, James (now Professor of Civil Engineering), were at Glasgow College together, and both are well remembered by those who were their class fellows. William Thomson was specially remarkable—an enthusiastic, eager little lad of twelve—jumping up to answer *viva voce* questions, when his chief difficulty was to make himself seen among his older class fellows.

From Glasgow William Thomson went to St. Peter's College, Cambridge, and in 1845 he graduated as Second Wrangler and first Smith's Prizeman; and he was elected a Fellow of his College. At Cambridge his main work was, it is needless to say, mathematical; but his tastes were by no means confined to this subject of his choice. Literature of all sorts and music had great attractions for him; and athletics were not neglected. He was President of the Cambridge University Musical Society for a time; and he won the Colquhoun Silver Sculls the first time they were rowed for at Cambridge. Anything 'with water in it' has a fascination for him—swimming, rowing, sailing, steaming, the Atlantic waves, his own Netherhall burn, the "rivulet down Trumpington-street," the capillary ripples made by a fishing line which is moved through a placid sea.

Even before his Glasgow student days came to an end we find Sir William Thomson's original work in science had commenced; and his first mathematical Papers, written before he entered Cambridge as an undergraduate, are well worthy of attention. They were both connected with the Fourier Mathematics, then but little known; and these early studies have probably given a colour to much of his subsequent work. In a Paper which was published in 1842, in the Cambridge and Dublin *Mathematical Journal*, on "The Uniform Motion of Heat in Homogeneous Solid Bodies, and its connection with the Mathematical Theory of Electricity"—written at the age of seventeen he points out the analogy between certain problems in conduction of heat and in the mathematical theory of electricity and magnetism; and he shows how to make use of solutions of the one set of problems in order to establish important conclusions with regard to the other class of questions.

The Papers just mentioned were followed by a Paper on "Linear Motion of Heat," which contained principles which he subsequently so powerfully applied to the question of "Geological Time." This was also published in 1842, and in 1845 he communicated to Liouville's *Journal de Mathématiques* a Paper on the "Elementary Laws of Statical Electricity." In October, 1845, and in June, 1846, he contributed to the same journal a letter addressed to Liouville, and an elaborate Paper on his principle of "Electric Images," a subject on which he seems to have spoken to the veteran mathematician during his residence in Paris about that time.

It is impossible, within the limits of the present notice, to discuss, or even to mention, the many Papers which flowed from the pen of Thomson about this time; but two somewhat general remarks which will be interesting to electricians may be made with respect to them. In the first place, the years about which we speak just now were of high interest and importance in the history of electric and magnetic science. The discoveries of Faraday in electrostatics and magnetism, and the ideas introduced by him, had given a new mode of thinking of some of these subjects. The function of the dielectric had been recently discovered and traced out, and the doctrine of lines of force had been expounded. Henceforward, action at a distance, so far as electricity and magnetism were concerned, was, so to speak, a notion of the past—an hypothesis utterly untenable and incapable of representing the facts of the case. Thomson early grasped this truth; and making the new knowledge the basis of his mathematical investigations, gave to its expression a mathematical form which endued it with fresh power.

The second general remark that we would make is this. At the age of seventeen Thomson, as we have seen, devoted himself to the study of attraction, and in his earliest Papers gave a large number of important general theories connected with this subject. The results of these investigations were very soon translated into the language of "the potential;" and the connection was established between these results and the theories connected with the science of energy which was coming into prominence through the labours of Joule. Thus it was that Thomson, at the age of twenty-one, became the exponent of doctrines, the full value of which can scarcely be said to have been appreciated before he was double that age. In 1867, or about that time, the word "potential," now so familiar to students and the merest beginners in electrical science, was unknown, except to a few mathematicians of the more advanced type. Can the Society of Telegraph-Engineers picture to itself the benighted condition of an electrical world like that?

In 1846 Thomson was elected Professor of Natural Philosophy in the University of Glasgow; and thus at twenty-two he was appointed to the chair which he has filled with such distinction and continues to hold. More than one offer has been made to him, the most tempting of which have been offers from the English University for which he entertains so affectionate a regard; but he has preferred to remain in his northern professorship, and his constancy is appreciated by the University which he adorns.

The dynamical theory of heat early engaged the attention of Sir William Thomson. His Papers on this subject were communicated to the Royal Society of Edinburgh. The first of these was published in 1849. Thomson was among the first to appreciate the importance of the work of Joule; and his earliest Paper on thermo-dynamics is occupied with a critical study of Carnot's "Réflexions sur la Puissance Motrice du Feu," published in 1824, and shows how the theory of Carnot may be altered so as to correspond with the modern doctrine regarding the nature of heat. His series of Papers on the subject of thermo-dynamics just mentioned form one of the most valuable and most remarkable of all the contributions with which Sir William Thomson has enriched physical science. The principle of dissipation of energy was announced in 1852; and in connection with these mathematical researches experimental determinations were undertaken by Joule and Thomson, and more than one joint Paper of high value was contributed to science by these two life-long friends.

In 1855 was published Sir William Thomson's Paper on "Electro-Dynamic Qualities of Metals." It was given to the Royal Society, and was made the Bakerian Lecture for the year. It was while he was engaged in experimental work in connection with this research that Sir William Thomson began to make use of the assistance of his students; and this was the commencement of the Physical Laboratory of the University of Glasgow, which was in fact the first of Physical Laboratories.

The Bakerian Lecture has been followed from time to time by Papers on the same subject, and the lecture itself and its continuations have proved a veritable nursery garden from which healthy seedlings have been transplanted in all directions—in Scotland, to England and Germany, and even to far Japan. And, being nurtured and carefully tended, these have grown into goodly plants, greatly to the honour and glory of their cultivators.

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In 1855 and 1856 a new field opened itself to the genius of Thomson. The problem of ocean telegraphy had presented itself to the world, and very soon he was practically called upon to solve it. To give a complete history of this time, interesting as it is to electricians, is beyond our present limits. A brief sketch must suffice.

Following up the 1854 experiments of Faraday, Thomson had investigated mathematically the subject of *the retardation of signals*, and had given the *law of squares*, now so familiar to all telegraphers. When the possibility of laying down an Atlantic cable came to be discussed, it therefore became evident that a cable of such a length as 2,000 miles, unless of unprecedentedly large transverse dimensions, might prove a commercial failure on account of the slowness of the transmission of signals through it. Mr. Whitehouse, however, at the Cheltenham Meeting of the British Association (1856), endeavoured to disprove the law, and to show that much more speedy transmission of signals might, than according to it, be expected.

In September and October, 1856, we find Thomson answering the statements of Whitehouse in two letters to the *Athenæum*. These letters, if there were space at our command, we would gladly quote, on account of the interest of this piece of telegraph history. We must content ourselves, however, with a single sentence from one of them, which gives the key to Sir William Thomson's two years later solution of the retardation difficulty. In his letter to the *Athenæum* of October 24th, 1856, the following remarkable sentence occurs (*after* he has made very clear indeed the difficulties to be expected). . . . "although I have never been able to learn any particulars as to the experience of those who worked that telegraph (Varna and Balaklava Cable), I have the best possible reason now for knowing that, if nine letters per second have not been delivered by it, the fault, or rather I should say, the deficiency, has not been in the cable, but in the instruments." A week later, December 11th, 1856, a short Paper was communicated to the Royal Society, "On Practical Methods for Signalling by the Electric Telegraph."

The warnings of Thomson were not, however, accepted, and it was only when the 1858 cable was *completed* that the directors became thoroughly alive to the situation. Whitehouse, experimenting on the cable itself with the Morse instrument, and endeavouring to transmit a column of *The Times*, found that he was unable to send through it at the rate of *one word per minute*. Then the directors sent for Thomson, and demanded of him that he would give them, according to his knowledge and his promise, an instrument which should satisfy the conditions necessary for success.

Thomson, experimenting with the reflection of the image of a candle thrown from his concave eyeglass on a sheet of white paper in a fairly lighted room, judged that the flame of a paraffin lamp reflected from a silvered mirror of one-tenth of that area would give an image bright enough for conveniently reading telegraphic signals. This was the first idea of the mirror galvanometer. The trials were made in February, 1858, and the mirrors and the instruments were made by Mr. James White, a Glasgow optician, whose name is now familiar to every electrician. The mirror galvanometer was supplied for the 1858 cable. The directors of the Atlantic Company insisted that Thomson should go to sea with the expedition, and also that he should take a patent for his instrument. This was done, and the patent then taken out was the first of Thomson's many patented inventions. To take a patent was somewhat against his wishes. He was ready freely to give to the public the fruit of his labours; and the same remark applies to at least two others of his most remarkable inventions—the Sounding Machine and the Mariners' Compass. Sounding by pianoforte wire was offered to the Admiralty, and was described in *The Times* directly after the loss of the "Schiller," and the compass was also freely offered; but he found in each case that the only way of securing attention to inventions of importance was to patent them and work the patents. Returning to ocean telegraphy: in 1867 the siphon recorder was invented and patented, and three years later was brought into very general use. Up to the present time these two are the only instruments by means of which signals are read on the long submarine lines.

We have just mentioned the Sounding Machine and the Mariners' Compass. The perfecting of these instruments gave Sir William Thomson much labour and thought through the years from 1872 to 1876. Both of these inventions were made to fulfil demands which he had seen to be urgent, partly in the course of his cable-laying expeditions, and partly through his knowledge of navigation, a subject in which he has always taken a very deep interest. In 1876, with the same thought at heart, he published "Tables for Facilitating the Use of Sumner's Method for Finding the Place of a Ship at Sea." The general adoption of Sumner's method thus made simple for the navigator would be a reform in navigation greatly to be desired.

Space fails us to give a full account of Sir William Thomson's more recent work. For five or six years his inventive genius has occupied itself with problems in electricity transcending in difficulty, we may safely say, any previously offered to inventors. To produce instruments capable of being used in the still novel work of electric lighting and electric transmission of power is the question of the day for many minds of high order. If we content ourselves with a 1 per cent. accuracy, or an accuracy of 1½ per cent., the problem is, perhaps, not too difficult to be satisfied with somewhat ordinary instruments, though most of the measuring instruments at present offered to users will scarcely be found to be reliable to this extent when fairly tested. Sir William Thomson, however, is not content with a standard so inferior; and his electric balances, which have recently and from time to time been described in these pages, certainly reach a far higher degree of trustworthiness.

A mere mention must now suffice of some interesting points in Sir William Thomson's history. In 1876, he was, in Philadelphia, a judge at the Centennial Exhibition. In 1880 he was, at Paris, a delegate to the Electrical Standards Conference, and at this time he was decorated Commander of the Legion of Honour of France. In 1883 he was in Vienna, at the International Exhibition; and in 1884 he received from Berlin the "*Ordre pour le Mérite*." In 1884 he once more crossed the Atlantic to deliver a course of lectures "On Molecular Dynamics," at Baltimore, to a "class" composed mainly of Professors from different parts of the world gathered together at the Johns Hopkins University.

Sir William Thomson is an honorary graduate of half the Universities in Europe. He is a Fellow of the Royal Society, President of the Royal Society of Edinburgh, Member of the Institut de France, the Accademia dei Lincei at Rome, the Berlin Academy, as has been already mentioned, the Amsterdam Koninklijke Akademie, the American Academy of Arts and Sciences. He has a multitude of medals, gold, silver, bronze, iron, awarded for various Papers and inventions, and numbers of addresses of greeting and congratulation.

Of himself, we will only say that his genius is at the least equalled by his gentle kindness and his single-minded modesty of disposition. These qualities are conspicuous in his daily intercourse with his students and his younger fellow-workers; and they make him the most beloved of teachers and associates.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

SIR WILLIAM THOMSON'S PRESIDENTIAL ADDRESS.*

"Electricity, Ether and Ponderable Matter."

(Continued from page 306.)

The telephone, one of the added subjects of the Institution of which we are members, illustrates very splendidly these developments of the theory of the transmission of signals through the submarine cable. The telephonic signals have, in fact, sufficient frequency to make electro-magnetic induction very sensibly influential. The frequencies in telephony correspond to from 250 periods per second up to two, or three, or four times that; being the frequencies involved in speaking in the human voice —tenor and soprano—and in the quality of the voice as affected by the over-tones. I say frequencies of from 250 per second to 1,000 or 1,500 periods per second are concerned in the

* Revised by Sir William Thomson.

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fundamental notes, and in the characterising over-tones, of the sounds transmitted by the telephone. Now, there seems no doubt but that the clearness of the telephone through great distances is to a large degree due to the circumstance which Heaviside has pointed out—that we have much less of difference of attenuation and difference of phasal retardation, for different notes, with the actual frequencies of the notes in sounds transmitted through the telephone wire and the practical dimensions of the telephone wire, than we should have without electromagnetic induction (hear, hear).

I cannot speak on this subject without just touching upon a question which I do not at all propose to enter upon to-night, and that is, the relative efficiencies of iron and copper as telephonic conductors. Information given to me by Mr. Bennett, the engineer of the National Telephone Company in Scotland, leaves no doubt whatever but that there is a very considerably greater loss of clearness in speaking through an iron wire—such, for instance, as the first metallic circuit iron wire of the Post Office between Glasgow and Edinburgh—than there is in speaking through the present copper wire circuit of the Company between the same stations. I shall say nothing more of this just now. It is an exceedingly difficult and complicated subject. But Heaviside's mathematical work, and Lord Rayleigh's experimental investigations on the susceptibility of iron to very small differences of magnetic force, differences of magnetic force superimposed on even a powerful magnetic force or a large residual magnetism, put us, I think, in a very hopeful condition. The subject is in good hands, mathematical and practical, and I think before many months pass over the Institution of Electrical Engineers we may have an absolutely clear understanding of telephony through iron wire as compared with telephony through copper wire (applause).

Leaving all questions of submarine telegraphy, and of telegraphy or telephony, in which, whether from the greatness of the distance through which the communications are made or smallness of distance between insulated conductor and sheath, or between the twin wires when insulated metallic circuit is used, the effects of electro-static capacity give rise to sensible difference of strength of current in different parts along the length of the conductor, I wish to call your attention to the differences of current density across different parts of the cross section which are produced when alternate currents are sent through a wire. Consider a copper wire and a copper tube surrounding it for return. Or consider what is, after all, one of the very simplest cases, two parallel copper wires. If the distance between them is a large multiple of the diameter of each, as is the case in practical telegraphy and telephony, the problem is the same as the problem of a single copper wire in the centre of a cylindrical tube of infinitely conductive metal, and of radius equal to the distance between the wires. The distribution of current within the solid conductor depends only on the period of the alternations, and on the diameter and the specific resistance of the metal; and is quite independent of the surroundings, provided only they be symmetrical all round, or provided, if the case be that of two parallel wires, the distance between the two wires be a large multiple of the diameter of each, so that the current in each is not sensibly disturbed by the influence of the other from being arranged in co-axial cylindric layers of equal current density. For this problem the mathematical theory gives us a remarkably interesting and very useful practical result, and I really, in proposing to speak upon such a very abstruse and uninteresting subject as electricity, ether, and ponderable matter, wish to try to give one little piece of practical information to night. It will be no information to some, but it may be information to others (hear, hear). The solution, expressed in a formula, and a table of numerical results calculated from it, I hope, will appear complete in the report of this address. I think I might give you just now two or three of the numbers that are rather interesting. Take 80 periods per second as the frequency—that is about what is adopted in the alternate-current system of distribution for electric light: at all events in one great system I know, the Grosvenor Gallery installation, that is the frequency of the period; and I believe it is pretty much the same generally. Let us take, then, as an example, the 80 periods per second. First, consider copper wire of one centimetre diameter: the ohmic effective resistance is greater than for steady current through the same wire, but not as much as $\frac{1}{100}$ per cent. greater. Take, now, copper wire of $1\frac{1}{2}$ centimetres diameter; the ohmic effective resistance is $2\frac{1}{2}$ per cent. greater than the resistance for steady current. Next, take copper wire of 2 centimetres diameter; the ohmic resistance is 8 per cent. more for the alternating current than for the steady current. In round copper rod of 4 centimetres diameter the ohmic resistance is 68 per cent. more for the 80 periods per second alternate currents than for steady currents. In round copper bar of 10 centimetres diameter the ohmic resistance is 3·8 times what it would be for the steady current. In a solid copper cylinder of 100 centimetres diameter the ohmic resistance is 35 times greater than for steady currents. From 10 centimetres diameter upwards the ohmic effective conductance—that is, the reciprocal of the ohmic effective resistance—increases scarcely more than as the diameter simply, and not as the square of the diameter. The conductance for steady currents is as the square of the diameter all through. The effective conductance for alternate currents follows a law which can only be expressed by aid of Fourier-Bessel functions till we get to very great diameters. When we get to so great a diameter that the shell, or outer portion, of the wire into which the current is practically confined is moderate or small in proportion to the diameter of the wire, then, for diameters exceeding that, you can all see perfectly without calculation that the conductance is in simple proportion to the circumference, and therefore in simple proposition to the diameter. This very imperfect explanation of the results may give some idea which, I think, is of rather an interesting and important kind, but the figures will speak for themselves (hear, hear). With quadruple frequency the same figures apply to wires of half diameter. There we get the telephone problem. Four times 80 is 320, which is among the frequencies for telephonic notes: and for the 320 frequency, take the figures I have given, but with half the linear magnitudes. Thus, for instance, for copper wire of 1 centimetre diameter, transmitting musical notes of 320 periods per second, the ohmic resistance is 8 per cent. greater than the resistance for steady currents. For a copper wire 2 centimetres diameter, and frequency of musical note 320 per second, the ohmic resistance is 68 per cent. greater than the resistance for steady currents, and so on.

Another important development from this theory is that there is much less importance in the conductivity of the metal for telephonic work through extreme distances, than for ordinary electric work. The formula and figures showing the kind of relations between ohmic effective resistances for different speeds are, as we have seen, a little complicated; but I will only say that ultimately it is the square root of the resistance that we have to deal with instead of the simple resistance. Quadruple resistance is only twice as bad, speaking roughly, when the frequency is so great as to cause the effect of the ohmic resistance to be very much greater than the resistance for steady currents. The moral of this is, not that you may choose wire of bad conductivity; on the contrary, take the best conductivity you can get, whether for telephones or for electric light conductors, but shape the conductors so that the ohmic resistance shall not be too much augmented by the unequal distribution of the current.

In respect to electro-magnetic theory. We have a very fine analogy with viscous fluid motion which has been obvious, more or less, from the time the known laws of electro-magnetic induction were put into formulæ in the beautiful manner in which Max well put them—we have a very fine analogy, I say, with the diffusion of laminar motion into a viscous fluid and its analogue in the diffusion of heat by conduction through a solid, first pointed out by Prof. Stokes (applause). The actions concerned in the distribution of alternating electric current through a conductor such as copper, and the distribution of the motion of water in a viscous fluid disturbed by periodical tangential motions of its surface, follow identically the same law. Mr. Heaviside, referring to this, has well said that this analogy is very useful, because we can see the motions in a viscous fluid and understand them, and picture them to our minds, while it is much more difficult to fancy we see the distribution of electric

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current in a wire. Take, now, definitively this analogy for the distribution of electric current in a round copper wire through which alternate currents of electricity are sent. Take a viscous fluid in a tube in place of the conductor: move the tube to and fro with a regular alternating motion—a simple harmonic motion. In order that we may fulfil at all approximately what I am speaking of, the length of the tube must be very great in comparison with the diameter, and the place in which we consider the motion of the fluid must be at a distance of many diameters from the ends which we may suppose to be closed by frictionless pistons, limiting the fluid at its two ends. In the first place, if the fluid were not viscous, if it was perfectly liquid, you might move the tube to and fro; but the fluid inside of it would remain at rest. Water, however, would move; oil would move; the more viscous the fluid is the more liable it would be to experience motion in that way. Now, there is a perfect analogy between the alternating motion of the fluid transmitted inwards from the surface and the distribution of the electric current in a wire through which the effect of the alternating current machine is being conveyed.

Another very interesting analogy in which exactly the same law holds is the change of temperature of a conducting solid due to variations of external temperature. Imagine a column of rock or stone or metal, and, instead of moving our tube to and fro longitudinally, let the atmosphere surrounding our column be periodically varied in temperature; the law of the inwards progress of changes of temperature, the law of the maximums and minimums, and zeros of temperature, is identical with the law of the corresponding features of electric currents and of fluid motion. In each case we have a propagation inwards, with diminishing amplitude. In each case the rate of diminution of amplitude corresponds to the retardation of phase according to exactly the same law. I need not attempt at this time to state the law—mathematicians know it perfectly well. Now take another case. Here the thermal analogy absolutely fails us, but the fluid motion analogy still holds. Take a tube of fluid and give it an alternating motion—a periodically-varying motion round its axis which gives a tangential drag to the fluid in the inside. Now you can all see that the inwards penetration of the tangential drag, if the alternations of the motion be very quick, will follow the same law for the to and fro motion of the cylinder and for the rotatory motion of the cylinder. The question is this: Does the variation penetrate sensibly to a large distance in from the outside or not? If, for example, it penetrates in only the one-hundredth of the radius, then it is obvious that we shall have sensibly the same law of penetration inwards for the disturbance, whether for the case of the rotatory motion of the cylinder round its axis or of longitudinally to and fro motion. Exactly the same thing holds with reference to electro-magnetic induction. The one case of electro-magnetic induction that I mentioned first is the most important, being the telegraph and telephone case, but another very interesting case, and not at all without practical importance, is the penetration of induced currents into a copper or other metallic core within a solenoid. Take a common helix or solenoid: send an alternating current through its coil—you know what it does. It produces magnetic force, with lines of force parallel to the axis in the interior of the solenoid. But alternating magnetic force, through the copper, induces electric currents in circles perpendicular to the direction of the force. Thus we have currents induced as you all very well know in a solid metal core of a solenoid. A metallic core other than iron is a subject for investigation of an exceedingly easy kind. The Fourier-Bessel functions come in here just as they do in the other cases in which we are concerned with circular cylinders. If we have, instead of copper, an iron core, we must take into account its inductive magnetisation. This presents no *mathematical* difficulty if we suppose the magnetic susceptibility constant: and the same law of amplitudes and phasal retardation holds as for copper or other non-magnetic metal. The difficulties, both experimental and mathematical, to take into account the enormous differences of the inductive quality of iron with different degrees of magnetisation, and with reversals of magnetisation, and the great complications of the inductive effects on account of the "magnetic friction" in the iron introduce corresponding complications in the theory of the induced currents, and they are complications of a kind that are very formidable.

Now I can only just go on to say two or three words about an extension of that viscous fluid theory that allows us to take into account all that goes on both in air and in metal, and in different metals, whether in contact with one another or separated by air. For illustration, consider our two simple cases—parallel wires with alternating currents through them, and the cylinder rotated with a periodic motion of rotation alternately in opposite directions. The analogy is simply this. To represent different metals, densities of fluid in simple proportion to the electric conductivities must be taken. The viscosity must be the same in all. The representative of an insulator in this analogy is a massless fluid. By "massless" I mean devoid of inertia—perhaps I ought to say an "inertialess" fluid, because people attach other ideas to "mass" sometimes than "inertia," but in the strictest dynamical language "mass" is taken as the measure of inertia. An inertialess viscous fluid must take the place of air or other non-conductor; a viscous fluid of a certain density, but the same degree of vicosity, must take the place of lead. A fluid of twelve times the density of lead would take the place of copper, the conductivity of copper being, say, twelve times the conductivity of lead.

Time does not allow me to pursue the subject further in the way of illustration at present, but I must return to the second case later on, because I am going to speak of iron and rotation.

Now with reference to the electrostatic effect, the hopeless—I must not say "hopeless"—that is too large a word; we are never without hope in science (hear, hear)—I was going to use another word "despair;" well, I feel it desperately difficult, I feel the probability of my seeing the solution of it *is* hopeless. To merely introduce into the analogy electrostatic effect is very simple. Simply imagine an interface between the two fluids and give it such stiffness against change of shape as is required to cause it to fulfil the conditions which electrostatic knowledge and our knowledge of the laws of electric and electro-magnetic influence dictate to us. I say put in at the interface the requisite normal force, and you can extend the analogy to include the complete problem of the submarine cable, in which electromagnetic and electrostatic induction are both taken into account. But it is only by putting in, and in an arbitrary manner, a force at the surface to fulfil the requisite conditions, that we can complete the analogy.

The analogy I have just sketched cannot be considered as being in any respect a physical analogy. In it the analogue to electric current is not velocity of the fluid, it is not the molecular rotation of the fluid, it is a quality derived from the simple motion of the fluid; mathematically by the operation known as the laplacian operation—the laplacian of (u,v,w) is the electric current. Another way of putting it is the rotation of the rotation of (u,v,w), or the spin-flow of the spin-flow of (u,v,w). The word "curl" was introduced by Clifford and Maxwell, and has, I grieve to say, been adopted by Mr. Oliver Heaviside. It is the curl of the curl. I object to "curl," because "rotation" or "spin" is good and "curl" is bad; I object to it on that ground, but not only on that ground. I object to it also because it is connected with a kind of mathematical symbolism which seems to me not desirable and not instructive, and, above all, not convenient for any practical use in mathematics. This "laplacian" is too difficult a subject to explain, but I would by a case try to illustrate it. Take in the viscous fluid analogue what corresponds to the steady current in a wire. Think of the tube with viscous fluid and pistons as before. At one end of the tube press a piston in with a uniform motion, continued long enough to cause the fluid throughout the tube to come to a state of steady motion. In the neighbourhood of the piston the motion is disturbed by the rigidity of the piston; but go to a distance of ten or twenty diameters from the piston, and the motion of the fluid takes a perfectly regular character. (*Illustrating on black-board as Fig. 1*). Suppose *that* to be the inner surface of the tube. This dotted line represents a portion of the liquid which at one time is plane. A little later, while the fluid in contact with the containing surface remains unmoved in the doctrine of viscous fluid, as given by Stokes,

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there is absolutely no slip at the containing surface, this portion of the fluid, which was plane, becomes the paraboloid of revolution, which you see shown in axial section in the diagram. The velocity of the fluid is nothing at the bounding surface, and it is a maximum at the centre. Well, we have two functions derivable from the consideration of that distribution of velocity. The first is the rate of shearing of the fluid; the second is the rate of change per unit-change of distance from the axis of the rate of shearing.* The rate of shearing represented graphically is equal to the tangent of the inclination (T P N) of this curve to the transverse surface—the tangent of the inclination of the curve, being the angle which is represented by the letter i. Now, the rate of change from point to point of the rate of shearing is the analogue to the strength of the current, and that is uniform. So in this analogy of a viscous fluid forced through a tube we have not the fluid velocity equal to the electric current, but something else, quite intelligible; and the reason for it, in our analogy, is clear enough. But there is something interesting, perhaps, in this idea, that we have a super-subtle mathematical definition of electric current which is not fluid velocity. Well, now, perhaps someone will say, "Had not we better get an analogy in which a fluid velocity is equal to the velocity of the electric flow?" Well, I do not say whether we had better do so or had better not, but we do not otherwise than in the way I have defined get the working analogy; and there is an advantage in this analogy. It gives us a motion of which the rotation is the magnetic force. Mr. Heaviside rather overlooks that. He objects to Maxwell's vector-potential; I do not agree with him in his objection. If he had confined the objection to the "vector" and the "potential" (vector wholly bad, and potential bad in connection with the

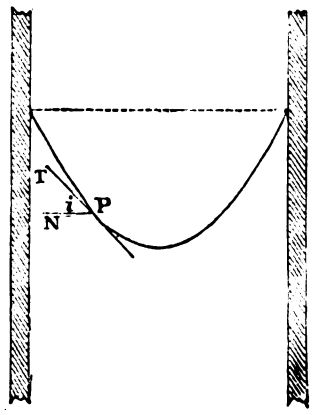

Fig. 1.

present subject), I would heartily have agreed with him, because I think it is an unhappily chosen name; but Maxwell's use of the thing (which he unhappily calls vector-potential) is most happy and most instructive, as it seems to me. Maxwell does not translate this into realities of motion, but he puts down in his formulæ as the foundation from which one step leads to magnetic force and the next step to electric current, something which translated into realities of motion gives us a motion of which the rotation is the magnetic force; and here it seems to me that if we are ever to have a real theory it must be founded upon this view. The hand of the clock warns me time is going on so rapidly that we must leave this analogy absolutely unfinished. Perhaps it is well to be obliged to leave it now, because the more we look at it the less we like it if we wish to see and to like a true mechanical explanation of electro-magnetism. The work is done in the wrong place. In the dense liquid, work is done, and heat generated in proportion to the square of the rate of shearing. In the electric analogue the work is done, and heat generated uniformly throughout the conductor. We have work done and heat generated in the viscous massless fluid taking the place of the dielectric in our fluid analogue. We must discredit that absolutely; but the reason for judging the analogy worth so much notice as even it has had to-night is that it is a perfect mathematical working analogy, and an exceedingly useful and instructive kind of analogy; and a very potent one to help us in guessing out, and in thinking out, and estimating results in practical problems of electro-magnetic induction in dynamos and in alternate-current machines, and in telephones and in electric instruments of great varieties of shape and mutual relations.

(To be continued.)

* Suppose the parabola in the drawing to represent the fluid which lay along the dotted line a unit of time earlier. The distance of P from the dotted line is equal to the velocity of the fluid (v), at the distance (r) of P from the axis. We have $u = c\,(a^2 - r^2)$; where a denotes the radius of the tube and c the fluid velocity along its axis. We have $\frac{-du}{dr} = 2\,c\,r$, which is the rate of shearing; and $\frac{-d^2u}{dr^2} = 2\,c$, which is our representative of the electric-current density. The whole strength of the electric current is $2\,\pi\,c\,a^2$.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section III.—Magnetic Fields of Coils and Solenoids.

(Continued from page 249.)

143. *Preliminary.*—The phenomenon which may be considered the most important and fundamental to be appreciated

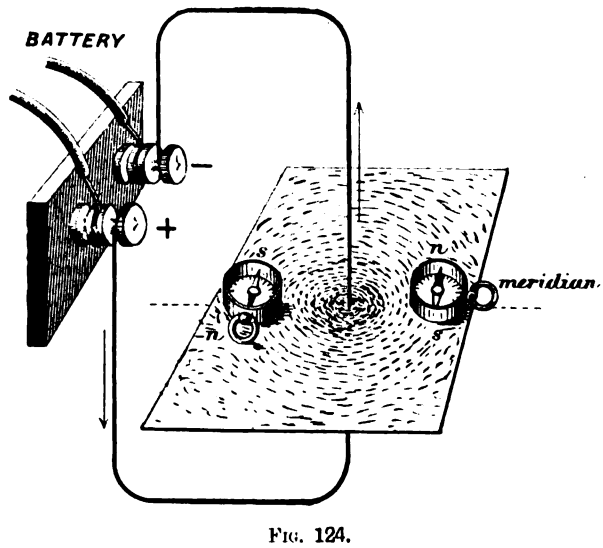

Fig. 124.

in dealing with this subject is that discovered by Oerstedt, of Copenhagen, seventy years ago, viz., the magnetic character of and effects produced by currents of electricity. A very simple experiment is sufficient to exhibit the magnetic field set up in the neighbourhood of a conductor carrying an electric current. A piece of stout copper wire, say No. 14, is pierced through the centre of a sheet of stiff cardboard (Fig. 124), and carried vertically for two or three feet before it is bent round to the terminals leading to a battery or other source of current. The card should be supported uniformly underneath, so as to present a flat, rigid surface, and the battery should consist of a few cells of large plate area, such as secondary batteries, in order to furnish a strong current. If the latter are used there should be an adjustable resistance between the battery and the experimental wire, which can be gradually reduced until the current is of sufficient strength to exhibit the effects, otherwise the experimental wire, being of neligible resistance, short-circuits the cells. Iron filings sprinkled over the card while the current is passing arrange themselves in circles round the wire. This exhibits the form of the magnetic field surrounding a straight conductor conveying a current, and demonstrates the magnetic character and properties of the current. What most concerns us in the use of this principle is the measurement of the field; in other words, we must be able to calculate the intensity and direction of the field at any point

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in the vicinity of the conductor. The direction of flow of the circular lines of force according to the usual assumption (para. 104) may be readily observed by exploring the same with a small magnetic compass-needle as shown in the figure. Suppose a line drawn across the card in the direction of the magnetic meridian, and two compass-needles placed on the line, one on each side of the conductor. Before the current is switched on to the wire the two needles will point along the meridian line, both, of course, with their north poles pointing towards the north. Now, if we connect the battery to the terminals, so as to send a current *upwards* through the wire, we shall observe on switching on the current that the needles move sharply into positions nearly at right angles to the meridian line, each pointing the opposite way. The north pole of the one on the right-hand side of the wire will point *away* from the observer, and the same pole of the other needle will point *towards* the observer, as shown. And if we move one compass needle round the wire, starting from one point and coming back to the same again, we shall observe that the needle turns on its pivot through a complete revolution—in other words, it shows the direction of flow of the curves of force to be continuous. According to the assumption that the north pole of a needle points to the direction of flow of the lines (para. 104), we find that, in this case, the flow is round the wire in the direction in which one would unscrew a screw (*a* Fig. 125). To remember the direction, perhaps the screw is the best analogy, for in unscrewing a screw we are moving it bodily upwards, *i.e.*, in the same direction as the current flows in the wire. The converse case (*b* Fig. 125) is with a descending current in the wire, the direction of flow of lines being reversed, and

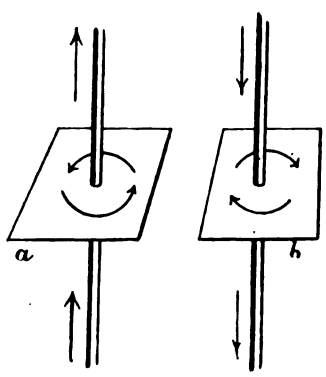

Fig. 125.

coinciding with the direction of turning a screw when screwing it downwards. Again, suppose we are using a spanner to screw a nut off or on a bolt, and we take the bolt to represent the conductor, and the direction in which the nut moves *bodily* along the bolt to represent the direction of the current in the conductor, then whichever way the bolt is placed, or in whatever direction the nut is moved, the direction of the circular lines of force round the conductor will always be the same as that in which the spanner is turned. The student will find it quite easy to recollect the direction of field for a given current by these practical analogies. In moving the needle round the wire it does not quite set itself as a tangent to the circle of force, because it is also affected by the earth's horizontal field, but with the strong current through the wire necessary to exhibit the circles of iron filings the earth's field has, in comparison to the circular field, very slight influence on the needle. It is this principle which enables us to find the direction of flow of a current in a conductor by the direction in which a compass needle, placed near it, sets itself (para. 66.) When a force acts along the circumference of a circle the *direction* of the force at any given point in the circumference is a tangent to the circle at that point, and this tangent is a line at right angles to the radius of the circle drawn from the centre to the point. If, therefore, we consider any one of the circles of force surrounding a conductor conveying a current, it is clear that, whatever point we choose in that circle, the magnetic force is acting there at right angles to the radius of the circle (drawn from the conductor to the point) and at a tangent to the curve. Further, if we consider two straight conductors side by side (Fig. 125), in which equal currents are flowing in opposite directions, it is evident that those portions of the circles of force which are between the conductors coincide in direction. The magnetic field at a point equidistant from both conductors, and in the same plane, is therefore twice the intensity of that which would exist if one of the conductors were removed—in other words, there would be twice the force acting on a magnetic needle placed at the point. But a still greater intensity of field may be produced at the point by bending the conductor into the form of a circle (Fig. 127), of which the given

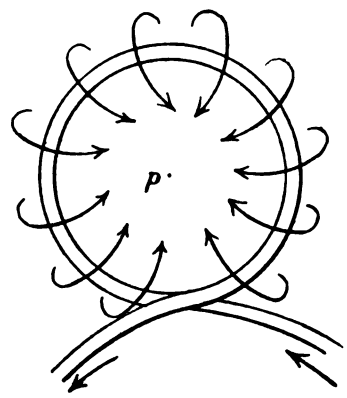

Fig. 127.

point is the centre. Here all the circles of force act in the most direct and efficient way, so as to add up their effects in one direction. This direction, by what has been said, will be understood to be entering the ring *from* the observer, the current being in the direction indicated by the arrows in the figure. The relative strengths of field produced (1) by the ring at its centre, *p*, and (2) by two very long straight conductors carrying the same strength of current, each of which is separated from the point by a distance equal to the radius of the ring (the conductors and the point being in the same plane), would be in the proportion of 2π to 4, or as 6·28 : 4. The same physical effect of multiplying the magnetic action by carrying the conductor completely round the point where the field is required, is obtained in the same way, whether the conductor is in a circular form or otherwise. We shall, however, confine ourselves to the circular form of conductor or coil, this being the general form for standard gal-

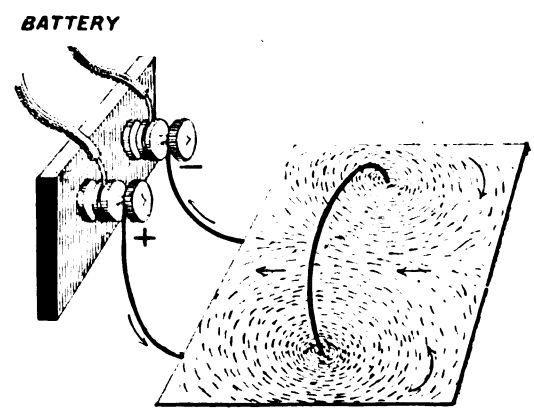

Fig. 126.

vanometers, and that which is the best for quantitively determining the magnetic field due to a current. The appearance of the lines of force, as shown by iron filings when the conductor is bent into a semi-circle, is shewn in Fig. 126, where the direction of the current and lines of force are indicated. The next step will be to point out the law by which the intensity of field in C.-G.-S. units due to a current may be determined, and to instance its application to solenoids and galvanometer coils.

(To be continued.)

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REVIEWS.

The Electric Motor, and its Applications. By T. C. Martin and J. Wetzler. (New York: W. J. Johnstone, 1888. Second Edition. Enlarged.)

We are pleased to see that a second edition of this valuable work has already been demanded. The opportunity has been taken to add four new chapters, which include descriptions of the latest European and American motors, both for direct and alternating currents. Most, if not all, of this information has already appeared in the columns of our contemporary, *The Electrical World*, of New York, but it is none the less welcome in volume form. Amongst the more important contents of the new chapters we may mention the very full description of the Bentley-Knight Electric Railway Company's System (see *The Electrician*, January 21, 1887, p. 240), comprising both overhead and conduit conductors; the Field Electric Locomotive and Street Railway System (see *The Electrician*, March 18, 1887, p. 419), the Short-Nesmith Series System (see *The Electrician*, April 29, 1887, p. 549), Irish's Conduit System (see *The Electrician*, January 6, 1888, p. 219), Schlesinger's Mining Locomotive, and various small motors designed for light work. The Lugo motor (see *The Electrician*, July 27, 1888, p. 385), in which the armature contains salient poles, would be regarded in this country as a decidedly retrograde step. On page 221 we read that a Schlesinger motor "designed specially for locomotives having to haul heavy loads" weighs with its gearing only 1,500lbs., and gives an output of 35 horse-power, or 1 horse-power for every 43lbs. of dead weight! This is a magnificent performance, and we should very much like to know how it is done. One of the most interesting and novel arrangements is that of Lieut. Patten, in which the armature is wound with three coils only, all of which are continuously in circuit in parallel with one another. Amongst other advantages claimed for this arrangement is that of absolute non-sparking for all positions of the brushes. The Immisch motor is described for the first time in this edition, but the particular machine described represents quite an early stage, beyond which Messrs. Immisch have advanced long since.

The chapter on "Alternating-Current Motors" contains an account of the interesting experiments of Prof. Elihu Thomson, which are based upon the peculiar action first investigated in this country by Dr. Fleming (see *The Electrician*, May 6, 1887, p. 561). This is followed by a reprint of the well-known Paper of Mr. Nikola Tesla, in which, however, it should be noted that the particular form now adopted by the Westinghouse Company is only incidentally referred to. The actual Westinghouse motor is not figured at all. The chapter ends with the statement that shortly after the publication of Mr. Tesla's work Prof. Galileo Ferraris published an independent investigation of the same kind. In the interest of chronological accuracy in this sentence, for the word "after" we must read "before." Prof. Ferraris' pamphlet reached this country in April, 1888, whereas it was not until May 15 that Mr. Tesla's Paper was read before the American Institute of Electrical Engineers.

The last chapter is devoted to Pyro-Magnetic Motors, and contains an account of practically all that has up to the present been done in this direction. It will be remembered that this subject was considered somewhat fully in *The Electrician*, Vol. XX., and the first description of M. Menges' ingenious motor appeared in our issue of January 13, 1888, p. 231.

In conclusion, whilst fully appreciating the value and importance of this work, we have to express our regret that in the issue of a second edition the authors have not thought it necessary to remove the theoretical mis-statements to which we called attention in our review of the first edition. It is really unfortunate that a work characterised by so much intelligence, and brimful of practical information, should retain such singular calculations as those of Mr. Rae in Chapter IV. We hope to see this section either omitted or entirely re-written in the next edition.

Die Erzeugung und Verteilung der Elektrizitat in Zentral-Stationen. By Dr. Mortin Krieg. (Magdeburg: A. and R. Faber.)

At the present moment it is not open to question that of all European countries central-station electric lighting has taken the firmest root in Germany; there is, therefore, plenty of ground for the production of the book before us. The preface states that its object is to be useful both to the engineer and the non-technical reader. Although interesting to foreign engineers, as giving some idea of German work, we fancy a German engineer will principally use it as a present to the ruling powers of the place in which he may wish to start a central station. There is just enough technical matter in it to make an outsider think it is a practical, not a popular work, and that he is very clever to understand as much as he does; while at the same time he learns that there is much quite beyond him, and that he must leave to the professional engineer. From the opening chapter on dynamos, which is very fully illustrated, we gain a good general idea of the "Dynamo Teutonicus." Taken as a whole, it is less remarkable for beauty than it is for strength, not to say dimensions, and perhaps originality is the kindest way of expressing another striking feature in many of the illustrations.

By-the-bye in the hybrid "D Teutonicus" and "D Americanus" the illustrations show the magnets formed of six vertical legs, as in the earliest Edison machines; surely this cannot be correct at the present day. Pretty full data are given of the various machines, and also of many of foreign manufacture as to output, efficiency, &c.

We must congratulate the author for his straightforwardness in reproducing one little remark concerning the Frankfort Gas Company's installation, viz., that the reason for employing English engines, boilers, and dynamos was that the contractors (not an English firm) had to guarantee the working of the installation.

The chapter on accumulators is to the point, but contains nothing very novel. The various systems of direct-current distribution are next discussed—series, parallel, three-wire, &c., with their various advantages; the disadvantages are generally not fully pointed out, which is a great mistake in a book of this sort. For example, a saving in the cost of mains of 43 to 45 per cent. (*sic*) is claimed for 7 and 10 wire systems; as if these were in any sense of the word practical systems. Diagram 43, representing an installation with batteries, is just what we should expect a learned professor to put down the first time he attempted practical work.

A number of more or less (principally more) complicated regulating devices are illustrated. We should be surprised if any one of them were to be found in a central station ten years hence, even in Germany.

According to Dr. Krieg there are only two makers of leads in Germany worth mentioning; that is no reason, however, for devoting a whole chapter, with illustrations, to matter whose proper place is in the said makers' catalogues. The Germans have always gone in for cheap and rough forms of instrument—rough, that is, in outward appearance—and several of the well-known forms are here described and cuts given of the outside appearance. When such a number of illustrations of unpractical devices are included it is a pity that none of the internal arrangements of the really practical ones are to be found. The meter exploited by Dr. Aron is well described, but no mention is made of the inventors, Profs. Ayrton and Perry.

We now come, when well past the middle of the book, to the nominal subject thereof—central station lighting. This is divided into three chapters, beginning with a recommendation that the town should lay down the installation, and then farm it out to a contractor for ten years. The arguments adduced on behalf of this suggestion are not very convincing. The rest of the chapter is principally a reproduction of Herr Fritzche's Paper in the *Centralblatt* in the beginning of last year.* In the most interesting chapter in the book—that descriptive of existing stations—while giving America credit for being first in the field, the author claims for Milan the honour of being the first town to start a central station in Europe.

Detailed descriptions are then given of a Westinghouse central station for 2,400 lamps at Trenton, N.Y.; two Berlin stations of 6,000 and 8,000 lamps; and Lubeck about 4,000

* An important extract from this Paper, showing curves of output for every month in the year for a Berlin station, will be found in *The Electrician*, June 29th, 1888, p. 244.

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10 candle-power. (It is instructive to compare the simplicity of the Trenton station with the extreme—otherwiseness, shall we say?—of this one.) The stations at Elberfeld, Amsterdam, and Ehrenfeldt are then described, as well as several now building; in fact, this chapter gives a good idea of the present state of things in Germany, and will doubtless be read with interest by many engineers in other countries. The great fault in most of the German centrals described appears to be complication. What is now wanted is for Teutonic engineers to go to the States for a while and learn simplicity.

The final chapter gives some methods for calculating networks, both graphically and analytically. A good deal of it is drawn from Herr Fritzche, and some of it, we think, we have seen in English some years ago. Though not really very complicated, it is calculated to impress upon the non-technical reader that the working out of networks is an unholy amusement which he had better leave entirely to his professional adviser. Perhaps this is the author's intention.

"The Bell Hanger's Handbook." (By F. B. Badt. Electrician Publishing Company, Chicago, 1889.)

This is a capital little book, giving the most detailed and explicit instructions for the fitting of all kinds of electric bells, annunciators, fire alarms, gas lighting fixtures, and other small fry of the same kind. It is abundantly illustrated, and ought to prove very useful to the class for whom it is intended.

TANGENT FUNCTION MULTIPLIERS TO BE USED WITH THE KAPP FORMULÆ IN THE DESIGN OF DYNAMOS AND MOTORS.

BY ALBION T. SNELL.

The armature iron is assumed to be saturated with 26 Kapp lines or 25,000 C.-G.-S. units, and the field-magnets with 18 Kapp lines or 17,300 C.-G.-S. units.

For Armatures and Fields.

Kapp Lines.	C.-G.-S. units.	Multipliers.	
		Armatures.	Fields.
1	960	1·00	1·005
2	1,920	1·01	1·013
3	2,880	1·01	1·021
4	3,840	1·02	1·041
5	4,800	1·03	1·069
6	5,750	1·04	1·104
7	6,700	1·04	1·147
8	7,650	1·08	1·202
9	8 650	1·11	1·273
10	9,600	1·14	1·362
11	10,560	1·17	1·489
12	11,500	1·22	1·654
13	12,500	1·26	1·891
14	13 450	1·29	2·250
15	14,400	1·40	2·853
16	15,350	1·49	4·624
17	16,500	1·57	7·707
18	17,300	1·79	infinite
19	18,249	1·96	
20	19,200	2·18	
21	20,169	2·52	
22	21,120	3·05	
23	22,080	3·92	
24	23,049	5·61	
25	24,010	10·82	
26	25,000	infinite	

In using the above multipliers the value of the magnetic resistance of the armature and field is first determined from the drawing or actual measurements, as detailed by Mr. Kapp. A suitable magnetic flux is then chosen. In the armature, say, $Z_a = 2\,a\,b\,\mu_a$, where a = the depth of the armature core, b = the length of the iron *less the insulation*, and μ_a = the number of lines per unit of area. The coefficient of leakage is assumed to be known or can be determined by experiment. This usually varies between 1·25 and 2·00. Z_a is then multiplied by this coefficient, and gives us Zf, which is the magnetic flux in the field-magnets.

The values of the armature and field-magnet resistances have now to be multiplied by the multipliers corresponding to the values of μ_a and μf ($\mu f = \frac{Zf}{\text{cross section of field}}$).

We have now $n\,c = \frac{Zf}{k\,R_a + k_1\,r_a + R'}$

and the number of ampere-turns to give Zf is known.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, January 25th.

Institution of Civil Engineers.

7:30 p.m. Students' Meeting. Paper to be read, "Water Softening and Filtering Apparatus for Locomotive Purposes, at the Taff Vale Railway Company's Penarth Dock Station, near Cardiff." By W. W. F. Pullen, Stud. Inst. C.E.

Society of Arts.

8 p.m. Indian Section. "The Asiatic Colonisation of East Africa." By H. H. Johnston, F.R.G.S.

Electro-Harmonic Society.

8 p.m. Smoking Concert at the St. James's Hall Restaurant.

Royal Institution.

9 p.m. "Meteorites and the History of Stellar Systems." By Prof. G. H. Darwin, M.A., F.R.S.

SATURDAY, January 26th.

Royal Institution.

3 p.m. Afternoon Lecture, "The Character of the Great Composers and the Characteristics of their Works." By Prof. Ernst Pauer.

Physical Society.

3 p.m. Notes on "Polarised Light," on "The Structure of Natural Diffraction Gratings of Quartz," on "Ahrew's Modification of Delezenne's Polariser," and on "The Use of Two Quarter-Wave Plates in Combination with a Stationary Polariser;" and a Note on "A Relation between Magnetisation and Speed in the Dynamo Machine." By Prof. S. P. Thompson, D.Sc.

"On the Divergence of Electromotive Forces from Thermo-Chemical Data." By Prof. E. F. Herrmann.

MONDAY, January 28th.

Society of Arts.

8 p.m. Cantor Lecture II., "Egyptian Tapestry and Textiles." By Alan S. Cole.

TUESDAY, January 29th.

Royal Institution.

3 p.m. Afternoon Lecture, "Before and After Darwin." By George John Romanes, M.A., F.R.S.

Institution of Civil Engineers.

8 p.m. Papers to be read, "The Steep Incline on the Puerto, Cabello and Valencia Railway, Venezuela," by John Carruthers, M.I.C.E.; "Cost of Working the Hartz Mountain Railway," by Robert Wilson, M.I.C.E.; "Further Information on the Working of the Fell System on the Kimutaka Incline, N.Z." By J. P. Maxwell, M.I.C.E.

Society of Arts.

8 p.m. Foreign and Colonial Section, "Gold and Silver Mining in Colorada." By T. W. Goad.

WEDNESDAY, January 30th.

City and Guilds of London Institute Old Students' Association.

7:45 p.m. Meeting at the Central Institution, Exhibition-road. Discussion on Mr. Albion T. Snell's Paper on "The Design of Electro-Motors."

Society of Arts.

8 p.m. Ordinary Meeting. "The Construction of Photographic Lenses." By Conrad Beck.

THURSDAY, January 31st.

Royal Institution.

3 p.m. Afternoon Lecture, "The Metamorphoses of Minerals." By Prof. J. W. Judd, F.R.S.

FRIDAY, February 1st.

Royal Institution.

9 p.m. "The Life History of a Marine Food Fish." By Prof. W. C. McIntosh, M.D., F.R.S.

***** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.**

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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THE DIRECTORY for 1889 will SHORTLY BE READY.

CONTENTS OF THE CURRENT NUMBER.

Supplement to this Week's Issue.

A STEEL-PLATE PORTRAIT OF SIR WILLIAM THOMSON, F.R.S., &c., &c., President of the Institution of Electrical Engineers.

Notes 325
Sir William Thomson 330
The Institution of Electrical Engineers.—Sir Wm. Thomson's Presidential Address. Illustrated. Continued 331
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 334
Reviews 336
Tangent Function Multipliers to be used with the Kapp Formulæ in the Design of Dynamos and Motors. By Albion T. Snell 337
Meetings of Scientific Societies. 337
The Aurora Borealis 338
The Insulation Resistance of Electric Light Installations. By Prof. A. Jamieson. Illus. 340
Legal Intelligence—
In re Gaulard and Gibbs' Patent.—Appeal. 343
The Electric Lighting of Dieulefit and Valreas. Illustrated. 345
American Notes 346
Notes from Paris 347
Notes from Brussels 347
Correspondence—
Telegraphy without Wires.—A. A. Campbell Swinton ... 348
Correspondence—*Continued.*
Mr. Edmunds' Method of Maintaining Constant Current.—Henry Edmunds and R. H. C. Neville 349
Refuse Destructors and the Electric Light.—F. W. Brookman 350
The Physiological Effects of Alternating Currents.—"Telegraphist" 350
Alkaline Accumulators.—A. E. Greville and H. J. Coates 350
Bath Electric Lighting.—H. G. Massingham, "A Disinterested Observer" and "Marsden" 351
"Ether."—E. T. Carter 351
"The Telephone," by Preece and Maier.—J. M., Jun. ... 352
Patent Record 352
Companies' Meetings, &c.—
Eastern Telegraph Company (Limited) 353
German Union Telegraph and Trust Company (Limited).. 353
The Manchester Edison-Swan Company 354
New Companies Registered ... 354
City Notes, &c. 355
Companies' Share List 356

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With this number of "The Electrician" is published a Supplement Steel Plate Portrait of Sir William Thomson, F.R.S., President of the Institution of Electrical Engineers.

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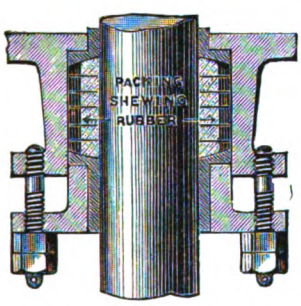

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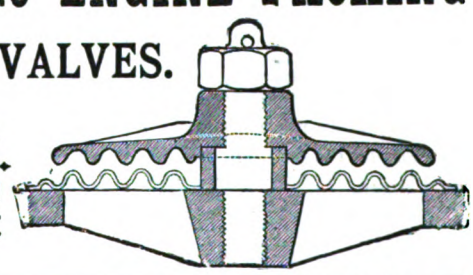

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"THE ELECTRICIAN" INDEX TO ADVERTISERS.

Advertisers in "The Electrician" have their names inserted under the following headings in this Index FREE OF CHARGE.

ACCUMULATORS. PAGE.
Drake and Gorham ..... —
Electrical Power Storage Co. .. 23
Elwell-Parker (Limited) 4

ALTERNATORS.
Anglo-American Brush Co..... 19

AMMETERS.
Nalder Bros. and Co. 11
Sharp and Kent ..... —

ANCHOR & SHIPS' SMITHS.
Moore (W. and E.) 20

ANTI-FOULING COMPOSITIONS.
Kirkaldy (J.) and Son 20

ASBESTOLINE.
Bell's Asbestos Company 24, 25

AUCTIONEERS AND VALUERS (Mechanical).
Wheatley Kirk, Price and Goulty 3

BATTERIES.
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
India Rubber & Gutta Percha o.14,18
Johnson and Phillips 1
Laing, Wharton and Down 2, 8
Latimer Clark, Muirhead & Co. 1

BATTERY JARS.
Joseph Bourne and Sons 2
Cannington, Shaw and Co..... 15
Gent and Co. ..... —
Price, Sons and Co. ..... —
South Yorkshire Bottle Co. 2
J. Stiff and Sons 6

BELTING.
Balderston and Co. ..... —
Moseley and Sons ..... —
Thompson and Rew ..... —

CABLE COMPANIES.
Anglo-American Telegraph Co. 27
Direct United States Co..... 27
Eastern Telegraph Co..... 28
Eastern Extension Telegraph Co. 28
Indo-European Co. 26

CABLE SUPPLIES.
Latimer Clark, Muirhead & Co... 1
Elliott Brothers 19
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co.14,18
R. Johnson and Nephew..... 2
Johnson and Phillips 1
Pirelli and Co. 6
M. Theiler and Sons 3

CARBONS.
Anglo-American Brush Co. 19
Barnaley Carbon Co..... 3
Belfast Electric Appliances Co.. 10
General Electric Co. 15
India Rubber & GuttaPercha Co.14,18
Johnson and Phillips 1
Laing, Wharton and Down 2, 8
C. A. Müller 3
Thompson and Rew (Carré) .... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 15

CUT-OUTS.
Electric Apparatus Co. 2
General Electric Co. 15
Wood (W.) and Co ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 15

CYCLOSTYLE.
Facsimile Apparatus Co..... 26

DISINFECTANTS.
Sanitas Co..... 18

DYNAMO MANUFACTURERS.
Allen and Co. ..... —
Anglo-American Brush Co. 19
Blakey, Emmott and Co..... 2
Clarke, Chapman, Parsons & Co. 9
Latimer Clark, Muirhead & Co.. 1
Crompton and Co. (Limited).... 14
Edison & Swan United Electric Light Co. 5
Elwell-Parker (Limited) 4
Fowler, Lancaster and Co..... 3
Gülcher (New) Electric Light and Power Co..... 18
W. T. Henley's Teleg. Works Co. 1
M. Immisch..... 21
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
Laing, Wharton and Down 2, 8
Laurence, Paris and Scott (Ltd.) 1
Paterson and Cooper 2
Sharp and Kent..... —
Statter and Co. 2
Telegraph Manufacturing Co. .. 10
Thompson and Rew ..... —
United Electrical Engineering Co. —
Western Electric Co. 21

EBONITE & VULCANITE.
Harburg India Rubber Co. ..... —
D. Moseley and Sons ..... —

ELECTRIC BELLS.
General Electric Co. 15
Gent and Co. ..... —
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
King, Mendham and Co. ..... —
London Electric Wire Co. 2
Julius Sax 2

ELECTRIC BELLS—(*cont.*). PAGE.
Western Electric Co. 21
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 15

EDUCATIONAL.
School of Electrical Engineering —

ELECTRIC LIGHT.
Anglo-American Brush Co. 19
Bernstein Electric Lamp Co..... 2
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 14
Drake and Gorham ..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 23
Elwell-Parker (Limited) 4
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
Gülcher (New) Electric Light and Power Co..... 18
W. T. Henley's Teleg. Works Co. 1
House to House Electric Light Supply Company 7
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down (Thomson-Houston) .....
Paterson and Cooper .....
Schmidt-Douglas Electric Co. .. —
Statter and Co. 2
United Electrical Engineering Co. —
Woodhouse and Rawson (Ltd.).. 15

ENGINEERS & CONTRACTORS
Allgemeine Elektricitäts-Gesellschaft, Berlin 3
Allpress and Belshaw 15
Anglo-American Brush Co. 19
Bernstein Electric Lamp Co.... 2
Booth, Ellson and Co. 7
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 14
Drake and Gorham ..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 23
Elwell-Parker (Limited) 4
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down 2, 8
Laurence, Paris and Scott (Ltd.) 21
Nalder Bros. and Co. 11
Paterson and Cooper 2
Phillips Bros. 2
Julius Sax 2
Schmidt-Douglas Electric Co. .. —
Sharp and Kent..... —
J. S. Starnes and Sons..... 4
Telegraph Manufacturing Co. .. 10
M. Theiler and Sons 3
Thompson and Rew ..... —
United Electrical Engineering Co. —
Verity (B.) and Sons..... 7
Woodhouse and Rawson (Ltd.).. 15

ENGINE PACKING.
Beldam Packing and Rubber Co. 15
Bell's Asbestos Company 24, 25
J. S. Starnes and Sons..... 4

ENGINES.
Bumsted, F. D. 19
Crossley Bros..... 22
Davey, Paxman and Co. 14
Marshall, Sons and Co..... 3
Ransomes, Sims and Jefferies .. —
Richards and Co. 12
Robey and Co. 4
Statter and Co. 2

EXCESS ALARMS.
Drake and Gorham ..... —

EXPANSION SHEETING AND RINGS.
Bell's Asbestos Company 24, 25

FENCING.
R. Johnson and Nephew ..... —

FITTINGS for ELECTRIC LIGHT
Crompton and Co. (Limited).... 14
General Electric Co. 15
Gent and Co. ..... —
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down..... 2, 8
C. A. Müller 3
Telegraph Manufacturing Co. .. 10
United Electrical Engineering Co. —
Verity (B.) and Sons 7
Western Electric Co. 21
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 15

FUSES.
Fowler, Lancaster and Co. 3

GALVANOMETERS.
Nalder Bros. and Co. 11

GAS LIGHTERS (ELECTRIC).
General Electric Co. 15
King, Mendham and Co. ..... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 15

GLOBES. PAGE.
Fowler, Lancaster and Co..... 3

INDIA RUBBER.
D. Moseley and Sons ..... —
Pirelli and Co. 6

INFLUENCE MACHINES.
King, Mendham and Co. ..... —

INSTRUMENTS.
Blakey, Emmott and Co. 2
Latimer Clark, Muirhead & Co. 1
Crompton and Co. (Limited).... 14
Elliott Brothers 19
General Electric Co. 15
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
King, Mendham and Co. ..... —
Nalder Bros. and Co. 11
Sharp and Kent ..... —
Statter and Co. 2
M. Theiler and Sons 3
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 15

INSULATORS.
Joseph Bourne and Son 2
Latimer Clark, Muirhead & Co. 1
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
Price, Sons and Co. ..... —
J. Stiff and Sons 6

IRON ROOFS & BUILDINGS.
Francis Morton & Co. ..... —

IVORY LABELS.
Endolithic Ivory Co. 7

LAMPS.
Anglo-American Brush Co. (Arc and Incandescent)..... 19
Bernstein Electric Co. (Incandescent) 2
Crompton and Co. (Limited).... 14
P. S. Dyer (Edison Incandescent) 2
Edison & Swan United Electric Light Co. (Incandescent) 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
Gülcher (New) Electric Light and Power Co..... 18
Johnson and Phillips (Arc) 1
Laing, Wharton & Down (Edison & Swan) 2, 8
C. A. Müller 3
Statter and Co. (Arc) 2
Sunbeam Lamp Co. 9
United Electrical Engineering Co. —
Western Electric Co. (Arc)..... 21
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 15

LIGHTNING CONDUCTORS.
Gent and Co. ..... —
Johnson and Phillips 1
King, Mendham and Co. ..... —
Julius Sax 2

LUBRICANT.
Bell's Asbestos Company 24, 25

MANUFACTURING ELECTRICIANS.
Latimer Clark, Muirhead & Co.. 1
Drake and Gorham ..... —
Electric Apparatus Co..... 2
Elliott Brothers 19
Elwell-Parker (Limited) 4
General Electric Co. 15
Gent and Co. ..... —
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
King, Mendham and Co..... —
Nalder Bros. and Co. 11
Paterson and Cooper..... 2
Julius Sax 2
Telegraph Manufacturing Co. .. 10
M. Theiler and Sons 3
United Electrical Engineering Co. —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 15

MEDICAL ELECTRICITY.
Institute of Medical Electricity. 15

MICA.
F. Wiggins and Sons 15

MOTORS (ELECTRIC).
Anglo-American Brush Co. 19
Elwell-Parker (Limited) 4
M. Immisch..... 21
Shippey Bros. (Limited) 12

NON-CONDUCTING COMPOSITION.
Bell's Asbestos Company 24, 25

PAINT.
Indestructible Paint Co. 26

PATENT AGENT.
J. C. Chapman 3

PLATINA SCRAPS.
Jamieson (W. & J.) 3

PRINTING AND ENGRAVING.
Waterlow and Sons (Limited) .. 356

POROUS CELLS.
Joseph Bourne and Sons 2
Price, Sons and Co. .. .. —
Stiff and Sons 6

PUBLICATIONS. PAGE.
Alternate Current Transformers 2
Dynamo Electric Machines 6
"Electrical Plant" ..... —
Electricians' Directory 17
Practical Electrical Measurement 11
Steam Engine Indicator 26
"Telegraph Convention" Codes. 17

REGULATORS.
Shippey Bros. (Limited)..... 12

RESISTANCE COILS.
King, Mendham and Co. ..... —
Nalder Bros. and Co. 11

SECOHMMETER.
Nalder Bros. and Co. 11

SECONDARY BATTERIES.
Drake and Gorham ..... —
Electrical Power Storage Co..... 23
Elwell-Parker (Limited) 4

SHIPWRIGHTS.
Napier (R.) and Sons 13
Turner (N. and K.) 7

SOCKETS.
General Electric Co. 15

SULPHURIC ACID.
Pearce (Wm.) and Sons 6

SUPPLIES FOR CABLE SHIPS
Fritz and Co. 26
F. Lack and Sons 26
Moore (W. and E.) 20
J. S. Starnes and Sons..... 4
Duncan Wallet and Co. 2

SWITCHES.
Crompton and Co. (Limited).... 14
Drake and Gorham ..... —
Edison & Swan United Electric Light Co. 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
General Electric Co. 15
Sharp and Kent..... —
Thompson and Rew ..... —
United Electrical Engineering Co. —
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 15

TELEGRAPH ENGINEERS.
Latimer Clark, Muirhead & Co.. 1
Elliott Bros. 19
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co.14,18
Johnson and Phillips 1
Telegraph Manufacturing Co. .. 10

TELEGRAPH PAPERS.
Waterlow and Sons (Limited) .. 356

TELEPHONES.
W. Blenheim and Co. 18
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
King, Mendham and Co. ..... —
New Telephone Co..... —
Stanhope Company 6
M. Theiler and Sons 3

TOOLS.
Fenn and Co. ..... —

TRANSFORMERS.
Elwell-Parker (Limited) 4
Sharp and Kent..... —

TURNERS.
Samuel Elliott 18

VALVE.
Mosses and Mitchell 354

VENTILATING ENGINEERS.
Blackman Ventilating Company. 3

VOLTMETERS.
Nalder Bros. and Co. 11
Sharp and Kent..... —

VULCANISED FIBRE.
Mosses and Mitchell..... 354

VULCANITE.
Harburg India Rubber Co. .... —
D. Moseley and Sons..... —
North British Rubber Co. 356

WALTHAM NON-MAGNETIC WATCHES.
Robbins and Appleton 6

WIRE (Covered or Uncovered).
Latimer Clark, Muirhead & Co.. 1
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
R. Johnson and Nephew..... —
Johnson and Phillips 1
London Electric Wire Co..... 2
Midland Electric Wire Co. .... —
Phillips Bros. 2
Phosphor Bronze Company 355
Pirelli and Co. 6
W. Rickard ..... —
Telegraph Manufacturing Co. .. 10
Wagener and Co. 11
Western Electric Co. 21

WIRE-COVERING MACHINES.
Barraclough and Co. 18

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Blenheim (W.) and Co.	Blenheim Englefield Green	—
Bourne (Joseph) and Son	Danesby London	7516
Bumsted (F. D.)	Bags Hednesford	—
Chapman (J. C.)	Powerful London	—
Clarke, Chapman, Parsons and Co.	Cyclops Gateshead	—
Crompton and Co. (Limited)	Crompton London	1663
	Crompton Chelmsford	—
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	Crossleys Openshaw	—
	Otto Glasgow	—
Davey, Paxman and Co.	Paxman Colchester	—
Direct United States Cable Co.	Direct London	—
Drake and Gorham	Accumulator London	3071
Dyer (P. S.)	Dyer Anvers	—
Eastern Telegraph Co. (Station)	Eastern London	1258
Eastern Extension Telegraph Co.	—	1107
Edison and Swan United Electric Light Co.	Ediswan London	3146
	Ediswan Ponder's End	—
Electric Apparatus Company (Limited)	Campanile London	—
"Electrical Plant"	Indices London	1533
Electrical Power Storage Co.	Storage London	838
Elliott Brothers	Ohm London	3852
Elliott (S.)	Samuel Elliott Newbury	—
Elwell-Parker Limited	Electric Wolverhampton.	—
Endolithic Ivory Company	Dendron London	—
Felten and Guilleaume	Fredennis London	559
	Carlswerk Mulheim Rhine	—
Fowler, Lancaster and Co.	Energy Birmingham	—
General Electric Co.	Electricity London	1887
Gent and Co.	Genta Electricians Leicester	—
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	Walter Glover Salford	1187
Gülcher (New) Electric Light and Power Co.	Gulcher London	9010
Henley's (W. T.) Telegraphic Works Co.	Henleys Works London	1734
Immisch	Immisch London	7585
India Rubber, Gutta Percha and Telegraph Works Company	Silvergray London	1726
Jamieson (W. and J.)	Dental London	—
Johnson (R.) and Nephew	Johnsons Manchester	—
	Johnsons Ambergate	—
	Resistance London	887
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King, Mendham and Co.	Kingham Bristol	(*)25

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London Electric Wire Co.	Electric London	106
Marshall, Sons and Co.	Marshalls Gainsboro'	—
	Engine London	6648
Morton (Francis) and Co.	Dropper London	—
	Ironsides Liverpool	—
Moseley (D.) and Sons	Moseleys London	858
Mosses and Mitchell	Insulator London	—
New Telephone Co.	Phonic London	—
North British Rubber Company	Weba Edinburgh	—
	Weba Glasgow	—
	Weba Liverpool	—
	Weba Manchester	—
	Ebwa London	—
Paterson and Cooper	Patella London	6511
Phillips Bros.	Flexible London	5422
Phosphor Bronze Company	Phosphor Bronze London	4557
	Phosphor Birmingham	—
	Phosphor Liverpool	—
Price, Sons and Co.	Price Bristol	6620
Ransomes, Sims and Jefferies	Ransomes Ipswich	—
	Anglia London	—
Richards (Geo.) and Co.	Richards Altrincham	—
	Herodes London	—
Robey and Co.	Robey Lincoln	—
Sanitas Co.	Sanitas London	1011
Schmidt-Douglas Electric Company	Dynamo Bradford	—
Sharp and Kent	Megavolt London	3125
Shippey Bros. (Limited)	Shippey Electricians London	—
South Yorkshire Bottle Co.	Wilkinson Swinton Yorks.	—
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Starnes (J. S.) and Sons	Starnes Ratcliffe London.	—
Statter (J. G.) and Co.	Statter West Drayton	—
Stiff (J.) and Sons	Stiff London	4627
Sunbeam Lamp Co.	Sunbeam Gateshead	—
Telegraph Manufacturing Company (Limited)	Limited Helsby	—
	Concentric London	1935
The Electrician	—	2714
"*The Electrician* Electrical Trades' Directory"	—	2714
United Electrical Engineering Co.	Jablochkoff London	—
Verity (B.) and Sons	Electroler London	2648
Wagener and Co.	Wagener Altena	—
Wallet (Duncan) and Co.	Dunwallet London	618
Waterlow and Sons (Limited)	Waterlows London - wall London	—
Western Electric Co.	Relay London	—
	Electric Chicago	—
	Microphone New York	1533
Wheatley Kirk, Price and Goulty	Indices London	—
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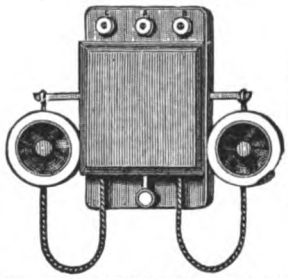

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the sun's influence* ; the secular variation is the only one whose connection with astronomical data still remains to be shown. The changes, however, which take place in the magnetic condition of the earth, important as they are not only in their scientific aspect, but also as they affect the seaman and the telegraphist, do not appeal very powerfully to the popular imagination.

There is, however, one phenomenon, hitherto placed in the same category, which is capable of commanding universal attention. The Aurora, even when seen from these latitudes, has a weird and strange appearance, but as displayed in the Arctic regions it presents one of the grandest spectacles which the eye of man can witness. Dr. SOPHUS TROMHOLT, of Bergen, who recently spent a winter amongst the Laps at Kontokœino, despaired of ever being able to convey an adequate idea of the grandeur of the sight. He speaks of waves of light rolling from time to time over the entire sky into the furthest corner of the heavens. Then would be formed the wonderful corona, of which all Arctic voyagers speak with so much enthusiasm, the "streamers" travelling upwards, sometimes in an arch like a rainbow, sometimes from all parts of the horizon, and meeting in the zenith. From one side of the sky to another a drapery, "woven of light and colour," is wafted. Now here, now there—first one, then two, then several bands, one above another, never at rest, and never the same form ; hither and thither the folds sway with a soft fascinating motion, as from one end to the other waves of light chase each other, overtaking, crossing, and meeting ; while the low intense border is described by Dr. TROMHOLT as displaying the liveliest colours of red and green, the upper one fading into the dark background.

No thoroughly adequate theory of this magnificent and mysterious phenomenon has yet been worked out. Most electricians and physicists have not got beyond the general idea that "electrical discharges in the higher regions of the atmosphere" are the proximate cause, and the facile analogy of the Geissler tube has perhaps tended to check a more exhaustive research. FRANKLIN'S theory is one of the most circumstantial, and has been very generally accepted. He supposed the difference of electric potential between the cold air of the polar regions and the warmer and moister air coming from the tropics to give rise to electrical discharges which take visible shape in the Aurora ; but this explanation obviously leaves a good deal unexplained, and in particular it assumes a much more intimate connection between auroral display and atmospheric electricity than has ever been shown to exist. Moreover, as we shall presently show, it altogether fails to stand the crucial test of spectrum analysis. Recently, however, the subject has been attacked from a new standpoint by Mr. NORMAN LOCKYER, and in a Paper of great importance, read before the Royal Society on January 10, he makes a suggestion which merits, as it will undoubtedly receive, the fullest consideration. Those of our readers who follow the general progress of physical science will not fail to be aware that in the Bakerian Lecture for 1887-8, delivered by Mr. NORMAN LOCKYER, he developed a very remarkable speculation, supported by elaborate and painstaking research, which tended towards a very considerable modification of the Laplacian theory of the evolution of the cosmos. This is not the place to attempt even the briefest summary of this brilliant speculation, but it may be said that it seeks to supplement the nebular hypothesis by attaching much greater importance than hitherto to meteorites. Planetary nebular and variable stars, as well as certain other astronomical phenomena which we cannot stay to mention, are referred to the collision and intersection of meteor swarms. The connection of comets with meteors is already fully established, and it may be said that the general tendency of late years has been towards an increasing recognition of the importance of meteorites in the economy of Nature. It has been calculated by Prof. NEWTON that not less than twenty millions of meteors, each large enough to be visible as a "shooting star," enter our atmosphere *daily* ; and in addition there must be a vast amount of "cosmic dust" too fine to be apparent to the naked eye.

Now it has long been known that the spectrum of the Aurora differs very considerably from the spectrum given by an electric discharge in air under any attainable conditions of temperature and pressure. The Aurora spectrum is, moreover, characterised by a bright line which had not hitherto been identified with any known element. The question was involved in additional obscurity owing to the fact that the recorded observations differed considerably amongst themselves, especially in regard to the exact wave-length of this particular line. As long ago as 1833, however, a suggestion was thrown out by OLMSTED to the effect that some connection might exist between the Aurora and shooting stars, and an examination of the recorded displays of either phenomenon since the beginning of the century exhibit a sufficient number of coincidences to lend some colour to the suggestion. This may be taken to represent the general state of knowledge on the subject when it was taken in hand by Mr. NORMAN LOCKYER. In the Paper which he has just read before the Royal Society, after discussing at considerable length the record of earlier observers, he is able not only to offer suggestions tending to clear up discrepancies, but also to bring new evidence of the most important character in favour of the hypothesis that the light of the Aurora is not of gaseous origin, but is due to electric discharges taking place amidst meteoric dust in the higher regions of the atmosphere. Everyone knows, however, that iron forms one of the most abundant constituents of meteorites, and it will therefore seem strange that there should have been any difficulty upon the above supposition in identifying the spectrum. *But as a matter of fact the Aurora spectrum does not, as a rule, contain the lines of iron.* Mr. LOCKYER'S explanation is sufficiently simple. The Aurora spectrum is produced at such a low temperature that only the more volatile substances are able to reveal their presence. The characteristic bright line he has identified as the remnant of the brightest fluting due to manganese. Now, when iron is raised to incandescence, this manganese line is invariably the first line to appear in the spectrum, and this is the case even with the purest electrolytic iron prepared by Prof. ROBERTS-AUSTEN. In the spectra of the meteorites at low temperatures, not only manganese, but also lead, thallium, carbon, and magnesium are rendered apparent before the iron lines begin to show themselves. Finally Mr. LOCKYER institutes a comparison between the spectrum of the Aurora and a compound spectrum built up of lines belonging to the above-mentioned elements at low temperatures, and in this way he obtains a series of coincidences which can scarcely be accidental.

Mr. LOCKYER is, however, content to remark that "the object of his Paper is mainly to direct further inquiries," and it still remains to be shown how far this theory can account both for the periodicity and geographical distribution of the Aurora, and its apparent connection with solar phenomena.

* See a Paper by Mr. J. A. Brown, F.R.S., *Proc.* Roy. Soc. XXIV., 1875-76, J. 231 ; also Prof. W. G. Adams, Brit. Association Report, 1881.

The Paris Exhibition Tramway.—The trams running between the Esplanade des Invalides and the Champs de Mars during the Paris Exhibition will be driven by electric locomotives.

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THE INSULATION RESISTANCE OF ELECTRIC LIGHT INSTALLATIONS.*

BY PROF. A. JAMIESON, F.R.S.E., M.INST.C.E., M.I.E.E.

Insulation Resistance of Land Lines and Submarine Cables.—In the early days of telegraph land lines and of submarine cables, *insulation resistance* was neither definitely specified for nor accurately measured during the various processes of manufacture and of maintenance. A few failures, however (in some cases dearly bought), soon impressed electricians with the necessity for paying more attention to this important quality, and they were not long in demanding from contractors the minimum of insulation resistance which would enable their lines to be worked with success. Not only are careful insulation tests now made during the manufacture of insulators and the erection of the land lines under the British Postal Telegraph Department, but "daily tests" are taken of all the more important lines. The minimum insulation resistance which each insulator should have depends upon the length of the line. For a line of 100 miles long each insulator is expected to give a resistance of 500 megohms, whereas for a line of only 10 miles 50 megohms is considered sufficient. When a line has been erected and put into working order it is usual to fix upon a minimum standard insulation resistance per mile. If the measured value at any time falls below this standard then the line is considered faulty, and steps are taken to remove the fault. The Post Office standard is 200,000 ohms per mile. In the cases of subterranean lines and of submarine cables an even still more rigid and careful system of inspection and of testing is now carried out during the manufacture of the cores and cables. The results are invariably reduced to an insulation resistance per unit of length at a standard temperature. The following extract from the specification of a successfully-made and laid cable will serve to illustrate this:—"The insulation resistance per knot of the gutta-percha core shall not be less, when tested at 75°F., than 300 megohms, fourteen days after manufacture and after two minutes' electrification. If the resistance of *any* portion of the gutta-percha (reduced to 75°F.) at any period of the manufacture fall below the above specified limit, the cable to be rejected." Throughout the whole of the operations of coiling and uncoiling a cable into the shore and ship's tanks, during the laying, and subsequently during its existence, the insulation resistance is periodically measured and tabulated.

Results of Neglecting Insulation Resistance in Electric Lighting.—We have been induced thus to particularise the extreme care and attention which is now considered absolutely necessary in the case of land lines and of submarine cables, because the industry of electric lighting has just passed through a similar experience to that which these industries met with in their earlier days. When the industry of electric lighting was first beginning to take root in this country, electric light engineers pooh-poohed the idea of accurately measuring the insulation resistance of any part of their work, and they invariably turned a deaf ear to the timely warnings of telegraph-engineers and electricians. Experience has, however, taught them, as it did their elder brothers, that good uniform insulation resistance throughout an installation is of immense importance, and that it cannot be obtained without careful attention to details and a rigorous system of testing during manufacture and erection, and also after completion. If an installation is not well insulated throughout, leakage of the current takes place, and consequently waste of power and money; electro-chemical action sets in where damp or liquids are present, and the conductor is thereby eaten through or a short circuit occurs, which for a time stops the whole of the lighting. Discredit thus not only falls upon the contractor, but others are frightened from employing the electric light.

Necessity for Discussing a Standard of Insulation Resistance.—The terms usually employed in regard to the insulation resistance of an electric light installation are, that it shall be "good" or "perfect," according to the fancy of the party purchasing the plant or of his adviser. These terms have, however, no specific meaning, and are therefore very variously interpreted. No doubt the society has had this subject before them in committee when drawing up their set of rules for the "prevention of fire risks;" but the Institution as a whole has never had an opportunity of discussing it, and thereby of impressing its members and the public generally with its importance, and the necessity for observing some minimum standard of insulation resistance. The writer had his attention directed the other day to a communication read before the International Society of Electricians, Paris, in November last, by M. Picou, wherein that gentleman ably analysed this question, and proposed a rule based upon tests of short lengths of cotton-covered insulated wire. He has not had an opportunity, however, of learning the extent and the nature of the discussion upon M. Picou's Paper, and he can only, therefore, place his rule before the members, along with a few other rules, and leave them to form their own opinions, guided by their practical experience.

General Propositions.—The following points will no doubt be readily admitted in regard to insulation resistance of electric lighting installations:—

1. That, owing to the comparatively low resistance of the conductor circuit of ordinary electric light installations on the parallel incandescent system, the minimum standard of insulation resistance does not require to be nearly so high per unit of length as in the case of submarine cables.
2. That it should be directly proportional to the electromotive force of the generator, or difference of potential between the conductor and earth, or between the forward and return conductors.
3. That it should be inversely proportional to the total length of insulated conductor, or to the total current, or to the number of lamps in circuit.
4. That, whatever rules or standards of insulation resistance may be adopted, they should be applied, not only to all the conducting wires, but also to the dynamo, the lamps, and all the fittings, or in other words, to the *whole* circuit.

Rules.—1882 *Set of Rules by Society of Telegraph-Engineers and Electricians.*—In May, 1882, in the first set of "Rules and Regulations for the Prevention of Fire Risks arising from Electric Lighting," issued by the Society of Telegraph-Engineers, no standard of insulation resistance or of minimum leakage is recommended. All that we find there on this head is: "The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by testing or probing with electric currents;" "All wires used for indoor purposes should be efficiently insulated," &c.; "The insulation of dynamo coils and conductors should be practically perfect;" "The value of frequently testing the apparatus and circuits cannot be too strongly urged," &c.

Five years ago even the writer is not aware that any published rule existed, or that any specification contained any definite rule for the insulation resistance of any part of any electrical installation.

Admiralty Rule.—About 1883 or 1884, however, the Admiralty officials requested that the insulation resistance of the dynamos supplied to them should withstand the test of stroking the free end of a conducting wire (the other end being connected to either pole) over any part of the framing without showing any signs of sparking when the machine was driven at its normal speed. The writer does not know whether they still insert this clause in their specifications, or whether they have modified or improved it; but at best it is only a rough-and-ready test, and gives no indication whatever as to the precise locality of a fault or its value in ohms.

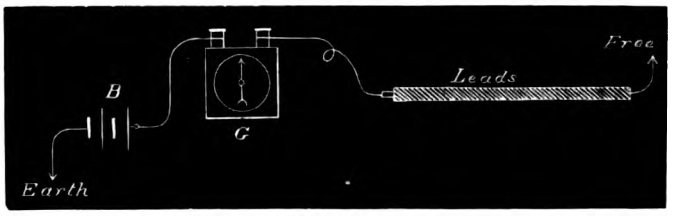

FIG. 1.

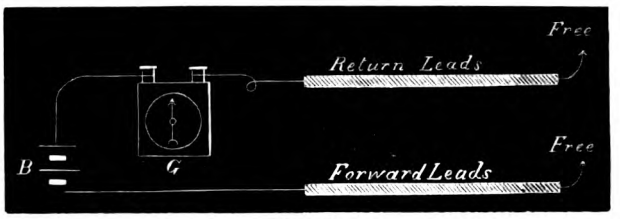

FIG. 2.

Workman's Tests.—The only test applied by contractors when wiring an installation was, and often still is, that of simply inserting an ordinary lineman's detector or galvanometer, G, between a battery, B (of one or two cells), and the leads, with the other end or ends freed, as in Fig. 1. If the galvanometer gives no deflection, or a very small one, then the section is passed as all right.

This is such an exceedingly simple and handy test for workmen that it can scarcely be improved upon, but it gives no precise indication whatever of the resistance in ohms, of the dielectric, or of the fittings. It simply informs the observer whether there is a bad fault or not. He can also find out by it whether the continuity of the conductor is complete, by earthing the further end; and he can also ascertain whether there is a short-circuit or not between any two or more "forward" and "return" leads by connecting up his apparatus as shown in Fig. 2.

* Paper read before the Institution of Electrical Engineers yesterday, January 24, 1889.

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In 1884 Messrs. Wm. Denny and Brothers' electrician used a small portable magneto-electric machine and sensitive bell — the same as telephone companies employ — instead of the above-mentioned galvanometer and battery. If the bell rang, a fault existed, and its position had to be found out; if it did not, then all was supposed to be right. He, however, in addition to this merely workman's test, applied a more exact test by Wheatstone bridge, and thus obtained the insulation resistance of the whole or of any desired portion of the circuit and the fittings in ohms.

Prof. Jamieson's Rule.—In 1884, whilst testing the electric light wires and fittings of some ships, the writer first drew up this rule, which has been published in the last three editions of Munro and Jamieson's "Pocket-Book of Electrical Rules and Tables." He had previously (since 1881) tested, by Wheatstone bridge, &c., the insulation resistance of a number of land and ship installations, and was rather surprised at the variety and lowness of the dielectric resistance, for his ideas of insulation resistance had been somewhat magnified by seven years' experience with submarine cables. At first, he could not get contractors to come up to his rule, but he was much gratified about this time by the enthusiasm and interest which Messrs. Wm. Denny and Bros.' electrician took in the matter, and by finding such good results in his tests of their ships' lighting leads, which results so far surpassed the demands of his rule that he decided to adhere to it. Since then, he has had much less difficulty, and when care and attention to cleanliness in jointing, to the fixing of wires and fittings, as well as in the manufacture of dynamos, are observed, he has frequently found that the insulation exceeded the demands of his rule, which is as follows:—"A careful insulation resistance test of each circuit, and finally of the whole of the circuits (including all switches and terminals, but not necessarily the lamps) joined up together, should be taken by the method described above,* and not passed unless the resistance is at least equal to ·1 Ω per lamp for every volt employed. The insulation resistance of the dynamo coils should be equally good."

Put into formula shape, the rule is—

$$R_I = k \frac{E}{N_L},$$

where R_I = the total insulation resistance of the whole or any part of the lamp circuits or of the generator in ohms;

k = a constant (·1 Ω = $\frac{1}{10}$ Ω = 100,000 ω) found from actual tests of several well-erected installations;

E = E.M.F. of dynamo or installation in volts;

N_L = number of lamps (16 candle-power) on each circuit or on the whole circuit.

The insulation resistance is therefore here taken to be *directly* proportional to the normal E.M.F. of the dynamo, and *inversely* proportional to the number of 16 candle-power lamps in circuit. The difficulty of ascertaining the precise length of the mains, sub-mains, leads and dynamo windings led the writer to substitute the number of lamps in circuit for what might at first sight appear to be the more exact term in the denominator, viz., the length of conducting wires employed. Although not stated in the above quotation of his rule, the writer usually applies the same test for the resistance or percentage leakage of current between the whole system of forward and return wires, also between the dynamo armature with field-magnet coils in circuit and the frame or body of the machine, as well as between the series and shunt-magnet coils if the dynamo is of the compound or series-shunt type.

The following example and table will make the application of this rule clearer:—

Suppose that we have an installation of 100 lamps of 16 candle-power each, and that the normal difference of potential between the terminals of the dynamo is 100 volts, then the insulation resistance should not be less than

$$R_I = k \frac{E}{N_L}$$
$$= 100{,}000\,\omega \frac{100\,v}{100\,L}$$
$$= 100{,}000\,\omega = ·1\,\Omega.$$

The leakage allowed by this rule in the case of 100-volt lamps using ·64 ampere of current per lamp is

$$C = \frac{E}{R} = \frac{100\,v}{10{,}000{,}000\,\omega} = \frac{1}{100{,}000} \text{ ampere of leakage}$$

for every lamp in circuit. Each lamp, however, requires ·64 ampere; consequently the leakage = $\frac{1}{64\,000}$th part of the total current.

Or, the percentage leakage = $\frac{1}{64\,0}$ = ·0016 per cent.

Since by the above rule the dynamo requires to have the same insulation resistance as the lamp circuit, the insulation resistance of the *whole* circuit, including the dynamo, is half of that given by the formula and tables, and therefore the leakage is double, or $\frac{1}{32\,000}$th part of the total current, or $\frac{1}{32\,0}$ per cent. = ·0032 per cent.

TABLE *of Insulation Resistances required by Jamieson's Rule.*
For 16 *candle-power Lamp Circuits and Dynamos.*

Number of Lamps in Circuit.	50-Volt Lamps.	65-Volt Lamps.	80-Volt Lamps.	100-Volt Lamps.	110-Volt Lamps.
	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	5,000,000	6,500,000	8,000,000	10,000,000	11,000,000
10	500,000	650,000	800,000	1,000,000	1,100,000
20	250,000	325,000	400,000	500,000	550,000
40	125,000	162,500	200,000	250,000	275,000
50	100,000	130,000	160,000	200,000	220,000
100	50,000	65,000	80,000	100,000	110,000
150	33,333	43,333	53,333	66,666	73,333
200	25,000	32,500	40,000	50,000	55,000
300	16,666	21,666	26,666	33,333	36,666
400	12,500	16,250	20,000	25,000	27,500
500	10,000	13,000	16,000	20,000	22,000
1,000	5,000	6,500	8,000	10,000	11,000

Phœnix Fire Office Rules.—In May, 1888, in the thirteenth edition of the Phœnix Fire Office Rules, Mr. Heaphy recommends that "in any electric light installation in which the current is continuous, and has an electromotive force of 200 volts or under, the insulation resistance over the whole circuit inside any buildings should never run below 10,000 ohms. . . . With currents of 1,000 volts the insulation resistance should never drop below 50,000 ohms, no matter how wet the weather may be. For alternate currents the minimum insulation resistance should be twice the above number of ohms respectively."

In November, 1888, in the fourteenth edition, Mr. Heaphy is more precise, and he has added a table based upon similar proportions to the writer's rule.* His Rule No. 27 reads as follows:—

"In any electric light installation in which the current is continuous, and has an electromotive force of 200 volts or under, the insulation resistance over the whole installation should not be below the following:—

"Installations of	25 lights	.....	500,000 ohms.
,,	50 ,,	.....	250,000 ,,
,,	100 ,,	.....	125,000 ,,
,,	500 ,,	.....	25,000 ,,
,,	1,000 ,,	.....	12,500 ,,

When the lights are proportionate between the above numbers, then the insulation resistance should be correspondingly proportionate. The insulation resistance of separate circuits of the installation should also be taken, and should be in accordance with the above table. For alternate currents the minimum insulation resistance should be twice the above number of ohms respectively."

Objections to Phœnix Rule.—The following objections may be offered in regard to this last rule:—

1. It ties down a contractor to one and the same insulation resistance, whether the E.M.F. of the installation lies *anywhere* below 200 volts. Surely a 50-volt installation requires but half the insulation resistance of a 100-volt one, and but one-fourth that of one with 200 volts.

2. It is somewhat doubtful (owing to a previous note to Rule No. 20) whether the words "over the whole installation" include the dynamo as well as all the wires, fittings, and lamps.

3. No distinction is made between circuits with one, or two, or more lamps in each parallel.

4. Arc lamps of 2,000 candle-power or more in parallel and large incandescent lamps of 500 candle-power or more, which require strong currents, come under the same general words, "any electric light installation in which the current is continuous," just as much as small incandescent lamps of, say, 5 candle-power, which require only a fraction of an ampere.

A question naturally arises here for discussion—Should not the insulation resistance in such extreme cases bear some definite proportion to the current?

* See Munro and Jamieson's "Pocket Book of Electrical Rules and Tables," p. 179, at foot. This rule applies only to the dynamos, leads, and fittings for incandescent lamps arranged on the single parallel system. Should the lamps be arranged in parallels, with two or three or more lamps in series in each parallel, they count as but one for each parallel.

* It will be observed that the above table corresponds identically with the writer's rule for an E.M.F. of 125 volts; *e.g.*, take 100 lamps: then

$$R_I = k \frac{E}{N_L} = 100{,}000\,\omega \frac{125\,v}{100\,L} = 125{,}000 \text{ ohms};$$

and so on in proportion to the number of lamps.—A. J.

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Westminster Fire Office Rule.—In 1888 the Westminster Fire Office issued a set of rules for guiding their officers in regard to electric light installations, in which they demand that the insulation resistance shall in no case be less than 150,000,000 ohms per mile ! ! ! Surely they have been blindly making extracts from a submarine cable specification ! No contractor could be expected, under ordinary circumstances, to complete his work (including dynamo and fittings) to such a high standard.

M. Picou's Rule.—On November 7th, 1888, M. Picou communicated his rule to the International Society of Electricians, Paris. Using the same symbols as in the writer's rule, it is—

$$R_I = k \frac{E}{C},$$

where R_I = the total insulation resistance of the circuit in ohms ;
k = a constant (500) found by experiments with short lengths of wire covered with three layers of cotton wound in reverse layers and pressed between metal plates.
E = maximum E.M.F. of the generator in volts ;
C = total current generated or passing through circuits in amperes ;
$\frac{E}{C}$ = the resistance in ohms of the whole circuit when the installation is in full working order.

The differences between M. Picou's rule and the writer's lie in the different values given to the constant k, and in the substitution by M Picou of the total current, C, for the total number of lamps, N_L, in the writer's rule. There is no doubt an advantage in thus substituting C for N , since the constant k thereby expresses directly the number of times the insulation resistance is of the apparent working resistance, $\frac{E}{C}$. And its reciprocal, the proportion which the leakage current bears to the total current. For, let c = the leakage current, and adopting the same symbols as above for the other terms, then

$$c = \frac{E}{R} = \frac{E}{k\frac{E}{C}} = \frac{C}{k},$$

$$\therefore \frac{1}{k} = \frac{c}{C} = \frac{\text{leakage current}}{\text{total current}}.$$

We, however, consider that M. Picou's constant, 500, is by far too low to ensure good and lasting work. By it, a circuit of 1,000 lamps of 16 candle-power each, requiring 100 volts and ·64 ampere each, the total insulation resistance of the circuit would only need to be 78·1 ohms, instead of 10,000 ohms by the author's rule (or 5,000 ohms if the dynamo be included).

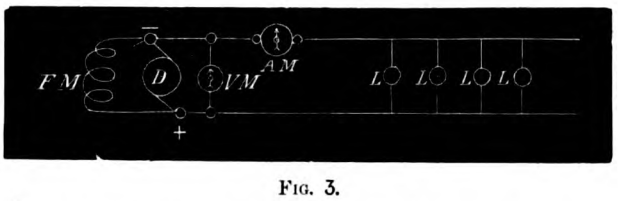

Fig. 3.

The Society of Telegraph-Engineers and Electricians' Last Rule.—In April, 1888, this society issued its second pamphlet of "Rules and Regulations for the Prevention of Fire Risks," and Rule 16 states that "the insulation of a system of distribution should be such that the greatest leakage from any conductor to earth (and in the case of parallel working from one conductor to the other when all branches are switched on, but lamps, motors, &c., removed) does not exceed $\frac{1}{5000}$th part of the total current intended for the supply of said lamps, motors, &c. ; the test being made at the usual working electromotive force." This rule includes all kinds and systems of electrical installations, and it is very neatly and concisely expressed. Some persons have, however, a difficulty in understanding how the $\frac{1}{5000}$th part of the total current is to be tested for or ascertained, and others do not see exactly how the test is to be applied to different parts of the circuits at the usual working E.M.F. *before* the installation is put into working order.

If the rule had also been put into the following form, with a table giving the insulation resistances required for a few of the more common electromotive forces and currents (or number of lamps), it would no doubt have recommended itself more readily to those unaccustomed to deal with the form of expression used in the rule. Using the same symbols as before, we have—

$$\frac{1}{5,000} C = c = \frac{E}{R_I}$$

$$\therefore R_I = 5,000 \frac{E}{C} = k \frac{E}{C},$$

which is the form of expression used before, and most easily applied. This gives a constant ten times as great as M. Picou's, and about one-tenth that of the writer's rule. Which of these constants is most in accordance with good practice ?

Table *of Insulation Resistances required by the Society of Telegraph-Engineers and Electricians' Last Rule,* viz., the leakage of any part of an installation not to exceed* $\frac{1}{5000}$*th of total current supplying that part ; or,* $R_I = 5,000$ E/C.

Number of Amperes in Circuit.	For 50-Volt Lamps.	For 65-Volt Lamps.	For 80-Volt Lamps.	For 100-Volt Lamps.	For 110-Volt Lamps.
	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	250,000	325,000	400,000	500,000	550,000
10	25,000	32,500	40,000	50,000	55,000
20	12,500	16,250	20,000	25,000	27,500
40	6,250	8,125	10,000	12,500	13,750
50	5,000	6,500	8,000	10,000	11,000
100	2,500	3,250	4,000	5,000	5,500
150	1,666	2,166	2,666	3,333	3,666
200	1,250	1,625	2,000	2,500	2,750
300	833	1,083	1,333	1,666	1,833
400	625	812	1,000	1,250	1,375
500	500	650	800	1,000	1,100
1,000	250	325	400	500	550

* If we include the dynamo as well as the whole of the lamps, motors, &c., will the insulation resistance of the *whole* installation be half the above figures ?

Different Tests.—The ordinary Wheatstone bridge test is the handiest and easiest method of ascertaining the actual resistance in ohms of the conductors as well as of the insulation resistance. Should the insulation, however, be too high for the battery power and the galvanometer, then the direct deflection substitution method may be adopted. These tests are so fully described in every book on testing, and are, besides, so well known, that there is no need to explain them here. The battery power need only be a few Leclanché cells (10 or 12 at most) if the galvanometer used is of the sensitive-mirror Thomson type.

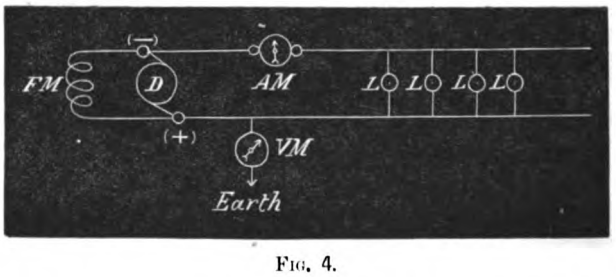

Fig. 4.

When the installation has been completed, then the whole of the results may be obtained by means of ordinary ampere and volt meters.

First, join up the circuit as follows, in Fig. 3. Work the installation at its normal power and observe the total current, C, by the ampere-meter, A M, and the difference of potential E, by the voltmeter, V M. This gives us $\frac{E}{C}$.

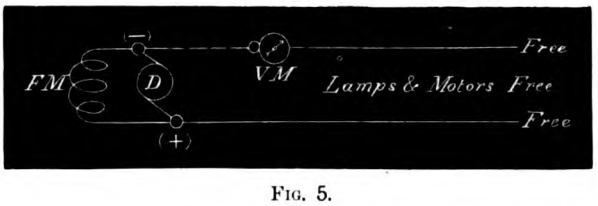

Fig. 5.

Second, join up the voltmeter as in Fig. 4, with one side to earth, having previously ascertained its resistance, r, ohms. Also note C on the ampere-meter, and see that it is the same as before.

If any leakage to earth exists in the dynamo or in any part of the circuit, a deflection on the voltmeter, V M, will be produced corresponding to the leakage current c passing through it, and is represented by e volts difference of potential between its terminals.

Then, $\frac{e}{r} = c$, the total leakage current.

But $\frac{C}{c} = k$, the actual constant or coefficient of the insulation resistance of the system.

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Then, if this value is greater than k, our standard constant, the installation may be considered all right as far as insulation resistance is concerned. Of course this does not inform us if any leakage is taking place between the forward and the return system of wires, or between the shunt and the series windings of the dynamo.

To ascertain the former of these, disconnect all the lamps and insert the voltmeter first in the forward lead, and secondly in the return lead, as in Fig. 5, and note if we get any leakage curcent, c, when the dynamo is run at its normal speed. In regard to leakage between the shunt and series windings of the dynamo magnets, recourse must be had to the Wheatstone bridge test.*

No doubt some of the members will suggest other practical tests, as well as give their experiences of how the insulation resistance of installations with which they happen to be intimately acquainted compare with the various rules herein mentioned, as well as how they stood the test of time and wear and tear of everyday work. What is chiefly wanted is to ascertain the minimum standard of insulation resistance compatible with good honest work and ordinary careful usage.

P.S.—Since correcting the proof-sheets of this Paper the writer thought that it might be interesting and instructive if he obtained the insulation resistance of an installation that had been working for some years, because members and others might say that some of the foregoing rules were all very well for *new* work, but were quite inapplicable to *old* work. He accordingly went to-day (January 16th, 1889) to Messrs. Graham's large East India offices and warehouses in Cathedral-street, Glasgow, with his testing apparatus, and took careful tests of the insulation resistance of the whole circuit, with the results shown in the following table :—

Original date of fitting up installation	1881-82
Date on which most of the wiring was renewed	1883
Date of test (day wet—Glasgow weather)	Jan. 16th, 1889
Total number of lamps in circuit of 16 candle-power each	281
E.M.F. at brushes of dynamo in volts	108
Current total from dynamo for all lamps, in amperes	(*about*) 160
Insulation resistance of dynamo armature and magnet coils alone, in ohms	40,000
Insulation resistance of the *whole* circuit, including the dynamo, *all* leads, switches, cut-outs, and lamps, in ohms	21,400
Insulation resistance to pass Jamieson's rule, including *dynamo* as well as the *whole* lamp circuit, in ohms	19,217
Insulation resistance to pass Society of Telegraph-Engineers and Electricians' rule (if their constant includes *dynamo* as well as the *whole* lamp circuit), in ohms	3,375

This old installation (the oldest large incandescent light one in Scotland), which has been in full daily working order for over five years (since the wiring was renewed), when tested without warning or any special preparation, and on a very damp day, gave a better insulation resistance than that demanded by the writer's rule, and over six times that required by the Society of Telegraph-Engineers' rule (taking it in its broadest sense).

It is worth mentioning that the President, Sir William Thomson, has taken a special interest in this installation from its very commencement. In 1881, when so few electricians knew practically how incandescent lighting should be carried out, and when the Messrs. Graham were erecting their large new premises, they consulted Sir William Thomson as to whether or not they could rely upon the electric light. Upon his recommendation they fitted their premises throughout with the electric light, without introducing gas-burners into any of their offices and warehouses. The actual carrying out of the present wiring of the building has been entirely done by one of the writer's students, who has had charge of the installation for the last six years The Messrs. Graham have been so pleased with the care and attention which he displayed that they have sent him to their new premises which they are at present erecting in Oporto, Portugal, to superintend the building and put up an electric light installation there.

The dynamo which the writer tested, and which gave a total insulation resistance of 40,000 ω, against framing and dead earth, is a Manchester shunt-wound machine by Messrs. Mather and Platt, put down about two years ago to replace the direct lighting of the building by three of the oldest shunt-wound dynamos in existence. These three machines are now employed in charging accumulators which serve to feed the lamps used in the darker parts of the building during the daytime. The writer tested the insulation resistance of one of these old machines, and found that it gave for armature and shunt coils just over 10,000 ohms, as against the frame of the machine.

In addition to the above tests, that indicated by Fig. 4 was applied, and no perceptible leakage current was observable on the voltmeter, even although the sensitive coil, which reads to less than a volt, was inserted.

The writer might give the results of several new installations which have surpassed his rule, and which therefore far exceeded the demands of the society's rule. He therefore thinks that the constant of the latter might be raised from 5,000 to 10,000 with perfect fairness, and with beneficial results to the electric lighting industry as a whole.

* For other tests when the installation is at work, *see* Munro and Jamieson's "Electrical Rules and Tables," Fifth Edition, pp. 215, 216.

LEGAL INTELLIGENCE.

In re Gaulard and Gibbs' Patent.

COURT OF APPEAL.—THURSDAY, JANUARY 17.

Mr. ASTON proceeded to deal with the evidence of Dr. Hopkinson. With reference to the question of anticipation Dr. Hopkinson was of opinion that the working of secondary generators in the way adopted by Messrs. Gaulard and Gibbs was an advantage, and said he did not know of any system that was in use prior to 1882 where secondary generators were worked in that way on a main circuit. He (Mr. Aston) was not aware that that evidence had been contradicted. The attention of Dr. Hopkinson was then called to particular cases where similar appliances had been adopted, the Jablochkoff system being first taken. Jablochkoff had in view, as he said in his title, a new process of producing and dividing the electric light. In 1878, though the general opinion was that it was impossible to have more than one light supplied by one machine, that notion of course had been proved to be entirely erroneous ; but at that time it was the notion which prevailed in many minds, and the object of these patents was to employ divided currents for small lights. There was, said Dr. Hopkinson, nothing in Jablochkoff's specification to show that it was intended to have a very long main wire and to have high tension on the main wire, and there was nothing in the Jablochkoff specification which would lead the minds of any person to employ the Gaulard and Gibbs system consisting of the three electrical elements which were the special subject of their patent. Jablochkoff's intention evidently was to divide the electric light and to obtain a high tension suitable to the lamp which he intended to use. Dr. Hopkinson's attention was then called to the Du Moncel system, which was dated in the same year. Dr. Hopkinson thought the system was in no way an anticipation of Messrs. Gaulard and Gibbs, and he gave similar evidence with reference to Bright's specification. With regard to Johnson's specification, Dr. Hopkinson said he thought it described a very inefficient induction coil which would be less useful than a Ruhmkorff, and it made no reference to the necessity for high tension. Dr. Hopkinson's attention was then called to the specification of Edwards and Normandy, and when asked if it was anticipatory of the specification of Gaulard and Gibbs he also gave a negative answer. There was no instance of any one of these systems having been brought into practical use. Their lordships might take it that the secondary generator described in Gaulard and Gibbs's patent was a known thing ; but no person had thought of sending currents of high tension through a long main wire by the aid of these secondary generators. If they had done so he would have had no case. Whether that would be subject matter or not it was for their lordships to consider. The question was—were these three elements used for the first time to secure that which Sir William Thomson called an important development? Having read the evidence of Dr. Hopkinson *in extenso*, Mr. Aston said he did not propose to deal in the same way with the evidence of the witnesses who followed Mr. Swinburne, Prof. Adams, Prof. Forbes, and Mr. Gibbs, who, he maintained, substantially confirmed Dr. Hopkinson, though it might be necessary to refer to some of their statements.

Sir HORACE DAVEY said he would have to refer to the greater part, practically the whole, of Mr. Swinburne's examination.

Mr. ASTON said in that case he would read the evidence, which he proceeded to do. He afterwards proceeded to deal with the evidence of Prof. Adams, who spoke of making use of alternating dynamo machines with a current of high tension to work the secondary generator as a novelty.

LORD JUSTICE COTTON : Is that a novelty ?

Mr. ASTON : Yes, my lord ; and so it was. There was not in any one of these prior machines an alternating current of high tension working secondary generators with divided cores.

LORD JUSTICE COTTON : That is not what the witness said. You introduce divided cores. He did not do that.

Mr. ASTON said the witness spoke of working the second generator, and the divided core in the generator was part of Gaulard and Gibbs's system. Witness was further examined as to the Ruhmkorff coils and intermittent currents.

LORD JUSTICE COTTON : As I understand the term, intermittent means a current always in the same direction, but from time to time very rapidly broken (I do not know whether that is very material), and an alternating current is where the current goes round a different way, but returns to the machine.

Mr. ASTON : From terminal to terminal without being interrupted.

LORD JUSTICE COTTON : I understand that is the construction of the two terms ?

Mr. ASTON : That is the construction put upon them ordinarily. That is not denied.

Mr. MOULTON proceeded to read the cross-examination of the witness.

Mr. ASTON next referred to the evidence of Mr. Gibbs, the co-patentee, and was followed by

Mr. MOULTON, who proceeded to deal with the evidence for the defendants, the first and principal witness being Sir William Thomson.

A generating machine was then exhibited to the Court for the purpose of illustrating the Jablochkoff arrangement.

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LORD JUSTICE COTTON asked what was the action of the current?

Mr. MOULTON said he might almost call it sympathetic. A current passing in one direction generated a current in the opposite direction. It was the most extraordinary thing in the world. Induction coils were placed in the circuit of the machine, and the lamps were connected to the secondary circuits. Jablochkoff contemplated a number of lights being put on the circuit, and by varying the arrangement and dimensions of the bobbins he could give the requisite tensions to his currents to produce lights of very different intensities. Sir William Thomson was of opinion that in 1877 electricians would have been able from this specification to have arranged a system of distribution of electricity, but, as a matter of fact, it was not done at that time.

Mr. MOULTON said that Sir William, in answer to further questions, said that all that was done in Paris was in the form of arc lamps. Electricians had the key of the secret in their own hands, but there was not at that time the demand for doing the thing. It was early found that arc lighting could be done by putting a number of arc lights in series in connection with secondary generators or induction coils.

The Court adjourned until the following day.

FRIDAY, JANUARY 18.

Mr. ASTON, continuing his speech, pointed out that the witnesses for the patentees had said that the various inventions which were relied upon in all cases had something introduced which required to be removed or altered, or modified, or some addition was required to be made to every one of the prior specifications in order to make them fit Gaulard and Gibbs's invention. On the other hand, there was the evidence of Sir William Thomson, who said that the method of constructing induction coils either increasing the intensity by causing the secondary wire to offer a greater resistance than the primary, or by causing the secondary to offer a less resistance than the primary, in which case there was a less intensity than there was in the primary, was perfectly well known. The method of winding was perfectly well known. The quantity of wire that there ought to be on the bobbins was perfectly well known, as he (Mr. Aston) admitted in the opening of the case in the Court below. The secondary generator, according to Sir William Thomson, was well known, not only to scientific persons, but to scientific instrument makers. But no question was put to Sir William Thomson as to the combination of the three elements, which were the main feature of Gaulard and Gibbs's invention, though Sir William admitted that their secondary generator was of special construction, though not in any shape novel. He then proceeded to read the cross-examination of Sir Wm. Thomson, with a view to showing the state of public knowledge at that time, and he contended that the witnesses for the patentees were practically uncontradicted, and that there was no evidence of anticipation before the Court.

Mr. MOULTON then read the re-examination of the witness, and continued with the examination of Dr. Fleming.

LORD JUSTICE COTTON: Do you claim the use of secondary generators like those described?

Mr. ASTON: Yes.

LORD JUSTICE COTTON: Then I think I ought to ask you what is the peculiarity, what is the speciality of those generators?

Mr. ASTON: It is a generator which of necessity has a divided core—nothing else will do—a generator which is capable of being modified so as to give the requisite tension according to the work that has to be done. The withdrawing of the core points in that direction. If your lordship asks me if I claim for the withdrawing of the core, I do not, but I claim a secondary generator.

LORD JUSTICE COTTON: I understand you do not claim anything in the generator?

Mr. ASTON: Nothing.

LORD JUSTICE COTTON: But you say there must be a special kind of generator to make up the combinations which you claim?

Mr. ASTON: Yes.

LORD JUSTICE COTTON: I was rather led to ask the question, because you thought that originally you could claim the secondary generator described as your special invention.

Mr. ASTON: The patentees *did* think so.

LORD JUSTICE COTTON: You claim the divided core?

Mr. ASTON: And bobbins so arranged as to enable the generator to do the work required.

LORD JUSTICE LOPES: I understood you to say these were two essential elements?

Mr. ASTON: That is the case, my lord.

LORD JUSTICE COTTON: Would not that be the case with all secondary generators? The coils could be modified by convolutions more or fewer.

Mr. ASTON: In this case the variation is more easily provided for.

LORD JUSTICE COTTON: You mean to say by the number of these bobbins that are separated from one another.

Mr. ASTON: Yes, my lord, and it is to be borne in mind that you can arrange the bobbins in series.

LORD JUSTICE LINDLEY: I do not see why your induction coil may not be any induction coil which answers the purpose.

Mr. ASTON: Any induction coil which answers the purpose so long as it has a divided core and is capable of modification.

LORD JUSTICE LINDLEY: They all have the divided core now.

Mr. ASTON: No, my lord; out of the six or seven specifications that are relied on, three or four have the solid cores.

LORD JUSTICE LINDLEY: Sir William Thomson says that anybody making an induction coil now would make a wire core.

Mr. ASTON: I think they would, now we have told them for the first time what would answer, namely, using cores that will not give Foucault currents. Once you have a secondary generator which is capable of being so modified as to do modified work, that will be of the class which we require.

LORD JUSTICE LOPES: I understood the evidence to be that the old Ruhmkorff coil would not do.

Mr. ASTON: A solid core would not do.

Sir HORACE DAVEY: The Ruhmkorff coil never had a solid core.

Mr. ASTON: My claim is for an alternating dynamo sending currents of high tension through a long main wire, and I stand or fall by that. It was the entire combination which is a novelty. There is nothing that I or my witnesses said in the Court below which is contrary to that construction.

LORD JUSTICE LINDLEY: I understand one of the difficulties is that the proportions between the two wires are not disclosed. The sizes are but not the lengths, and we want to know the number of convolutions as well.

LORD JUSTICE LOPES: Must not that depend upon the use to which you are going to put the apparatus?

Mr. ASTON said that the number of convolutions would vary with the number of the lamps. Details of this kind could not be defined in a specification. Of course, when the attention of Sir William Thomson was directed to picking holes in the specification, he said these details were not there, but he (Mr. Aston) should contend that they were not details of a kind which would invalidate the patent. He now approached a part of the case to which it would be necessary for him to refer with great care. Assuming that it was true that the problem that Messrs. Gaulard and Gibbs set out in their specification had been referred to in prior specifications, he should contend that the object was different. In all these prior specifications (which he was going to examine *seriatim*) the object was different. And that it was likely to be different arose from this fact, that the lamps which were used in 1878 and 1879 were lamps for which it was not necessary to have very high-tension alternating currents that could be sub-divided so that the light of one lamp in the series should not, by being extinguished, interrupt the continuity of operation of the series. Sir William Thomson knew every one of the electrical facts disclosed in the prior specifications. He had himself endeavoured to solve the problem of the distribution of electricity over long distances, and he knew that there must be high tension, and if he had had the wit to see that there must be high-tension alternating currents he might have solved the problem. But his mind was upon direct currents. He knew all about induction apparatus; there was nothing new in that. Had he given a single instance where an induction coil had ever been used prior to this specification? Sir William Thomson was on the verge of the discovery. He had the ideas; he knew you must not introduce into a building electricity of such a tension as to be dangerous, and he thought to provide what was necessary by a storage battery. And a grand thing that storage battery undoubtedly was; it was beautiful, and no wonder that Sir William Thomson went breast high in hope that the problem was solved. But he had the wrong high tension. If he had put the induction coil in the place of the storage battery he would have solved the problem. Mr. Aston then proceeded to deal with the question of the validity of specifications generally, and quoted decisions of Lord Westbury and Sir George Jessel upon that point.

The Court adjourned until the next day.

SATURDAY, JANUARY 19.

Mr. ASTON, continuing his address, proceeded to refer to the specification of Edwards and Normandy, which, from the point of view of anticipation, no doubt came near to the specification of Gaulard and Gibbs. It was a provisional specification, which apparently was never completed. That fact, though not in itself conclusive, went, he thought, a long way. The specification stated the object of the invention was the improvement of electric lighting, so that the current of electricity obtained from magneto-electric machines or other apparatus might be made to produce as many electric lights as might be required, and in any desired positions or localities, and such separate lights might be extinguished or regulated without difficulty. That in the first place was a different object from that which Messrs. Gaulard and Gibbs had in view. Then the specification continued: "We take one or more magneto-electric machines of any of the well-known kinds." There appeared to be no limitation as to the kind of machine, or as to the kind of current which should be employed. The machine, the specification went on to say, was to be situated in any convenient central position in relation to the lights which were to be produced, and might be driven by steam or any convenient power, "so that a very rapidly intermittent current of electricity of any desired magnitude is produced from it, is conveyed along a metallic wire properly insulated in the usual way, and passes through or near every station or position where it is desired that a light should be produced." The witnesses for the patentees all said that an intermittent current had a particular meaning; it meant a current which was sent intermittently from the originator of electricity, was continuous as regards direction, and discontinuous as regarded supply. Dr. Hopkinson also gave evidence to the same effect, and that, said the patentees, was the fair reading of the specification of Edwards and Normandy. Sir William Thomson said that an alternating current was intermittent. Of course it was, but it was not intermittent as regarded the sending; it was not a current which was sent intermittently from the machine in one direction, being assisted by a make and break apparatus. He submitted that Sir William Thomson put a strained construction upon the words when he said that an alternating current might also in a sense be intermittent. That was impossible. The next clause in the specification was very important. "The circuit of the current"—that was the intermittent current—"is completed either by bringing the wire back to the machine at the generating station or connecting it to earth." Nobody had said that

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Gaulard and Gibbs had ever contemplated an alternating current connecting with the earth. The current they used was one which swept round from terminal to terminal. Whatever current might have been contemplated in Edwards and Normandy's specification, it was clearly not the alternating current of Gaulard and Gibbs. The same idea pervaded the whole of the specification, in which (if he were right) there was no direction as to the use of an alternating current at all. There was another statement which overrode the whole. "A sufficiently powerful galvanic battery may be used instead of a machine"; but though the battery would give an intermittent current with a make and break arrangement, it would not give the alternating current which Gaulard and Gibbs described Edwards and Normandy started by saying that any magneto-electric machine would do. Sir William Thomson said, applying his own knowledge, that of course people would select machines giving alternating currents; but that did not appear upon the specification, and Sir William Thomson, in going through the specification, ignored the direction to use intermittent currents rapidly produced.

LORD JUSTICE LINDLEY, in reference to the evidence of Sir William Thomson, said he did not know the difference between a dynamo and an electro-magnetic machine. Harrison's patent did not speak of dynamos, but of an electro-magnetic machine. He wished to know whether a dynamo sent a continuous current, and a magneto-electric machine an alternating current.

Mr. ASTON said a magneto-electric machine was a machine which had a permanent magnet.

Sir HORACE DAVEY: A dynamo has a magnet created by electricity.

LORD JUSTICE LINDLEY: They both send alternating currents, do they?

Mr. ASTON: Yes; but you might have a magneto-electric machine that sent a continuous current, and at this time the Siemens and the Gramme machines—which were being introduced as being very important machines—had the continuous current interrupted. As regards the specification of Edwards and Normandy, Dr. Hopkinson was asked this question: "Do you think that Edwards and Normandy's is a system which would lead anybody to employ the system of Gaulard and Gibbs?" To this the answer was "No." "Would it teach them what Gaulard and Gibbs's specification teaches them?"—"No." Mr. Aston then said he would refer, lastly, to the specification of Imray. Imray began with a low tension from a battery. The tension was raised by means of an induction coil, and high tension was used to go along the wire, but it was not the high tension produced from an alternating machine or of an alternating character. There was nothing about high tension in the specification of Edwards and Normandy, though if the current was sent over long distances, say 50 miles, there must be high tension. If the problem which Messrs. Gaulard and Gibbs had in view had been solved in the specification of Imray, he submitted that the matter would have been heard of in the Electrical Congress at Paris in 1881. There was no description in Imray of the Gaulard and Gibbs process. Mr. Aston concluded by appealing to the Court on behalf of a system comprising the following elements:—1, A high-tension alternating dynamo; 2, transmitting currents along a main wire at high tension; and 3, a main wire having at intervals local installations obtained by means of induction apparatus.

Mr. GRAHAM also addressed the Court, and claimed for the invention of Messrs. Gaulard and Gibbs four special features:—1, divided and movable core; 2, divided secondary arrangement (which could be coupled in series or in quantity); 3, high tension in the primary and low tension in the secondary; and 4, the absence of the make and break. Though the patentees could not claim the invention of these special features, they claimed the combination as a new combination, amounting in reality to a new invention. The way in which the petitioner framed his argument in the Court below was this: he minimised these special features, and he minimised them to such an extent that the learned judge was led to believe there was nothing in them. But speciality was the essence of the patent, though in itself it might be of very little value. Be that as it might, the patentees desired to keep it. Mr. Graham dwelt upon the importance of the divided core, and said that the state of electrical knowledge at the date of Gaulard and Gibbs's specification was such, that if any practical electrician had been told that what was claimed by the combination in the specification was possible, he would have laughed at the idea as an absurdity. The divided core prevented heating, and lamination also ensured economy of working. With regard to the Jablochkoff specification, he contended that it could not in any sense be said to have been an anticipation. The specification of Edwards and Normandy he described as a tissue of electrical absurdities and misdirections. Deprez no doubt provided for the transmission of electrical energy, because he said it was possible to heat a platinum wire at a distance of several hundred thousand yards by means of a battery consisting of two Bunsen elements; but he contended that could not be taken as evidence of Deprez's knowledge that electrical energy so distributed could be used for purposes of electrical lighting. Mr. Graham concluded by saying that if the patent was valueless, as was alleged, he could not see what object there was in revoking it.

LORD JUSTICE COTTON: We have not got to consider that; we have only to consider whether the patent is good or bad.

SIR HORACE DAVEY: My friend is trying to save his patent by minimising it.

The Court adjourned until Monday.

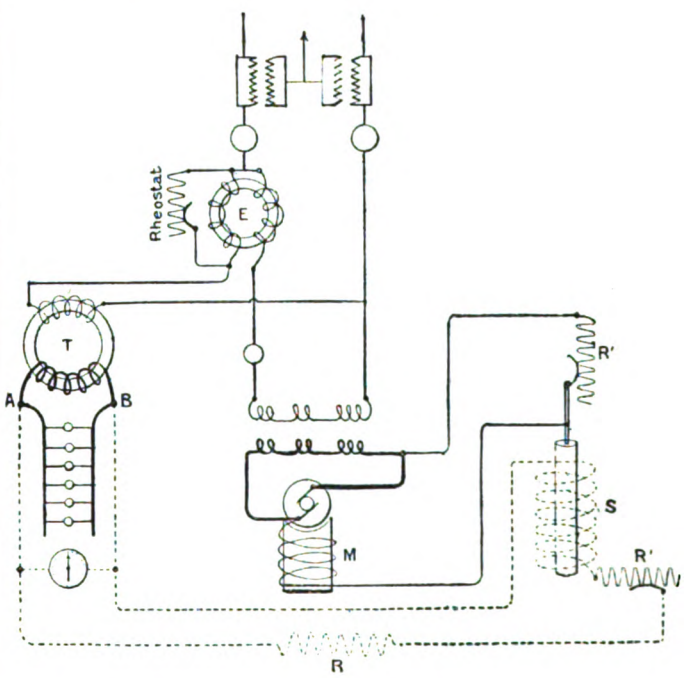
(To be continued.)

Russo-China Telegraph.—We understand that some French engineers have been despatched to Russia with a view to the laying of a telegraph line from Russia to China across Siberia.

THE ELECTRIC LIGHTING OF DIEULEFIT AND VALREAS.*

A central lighting station containing several features of interest was inaugurated near the town of Dieulefit on the 25th December last. The idea of lighting the towns of Dieulefit and Valréas from the same station was due to M. Charles Noyer, mayor of Dieulefit, and the execution of the project was entrusted to MM. Lombard Gerire et Cie., of Lyons.

The central station is situated at Béconne, which is 5 kilometres from Dieulefit and 14 kilometres from Valréas. The motive-power is obtained from the Lez, a short canal, taking the water to a 3,000,000-gallon reservoir. A fall of 25 metres is utilised, so that this reservoir represents a reserve of about 1,200 horse-power-hours, or nearly 800 electrical horse-power-hours available for lighting. An iron pipe 80 centimetres in diameter brings the water from the reservoir to the two 50 horse-power turbines, which run at 180 revolutions a minute. Each of these turbines drives an alternating-current Zipernowsky dynamo, giving 12 amperes and 2,000 volts, and its exciter, a shunt-wound machine giving 30 amperes and 80 volts. Each town is served by a distinct set of plant comprising the turbine, alternator and exciter. The reserve consists of a third alternator, which will shortly have a third turbine to drive it. The speed of the turbines is kept constant by a Bouvier hydraulic governor. This mechanical governing is, however, insufficient to keep the difference of potential constant at the lamp terminals, since the line resistance is 14 or 15 ohms, which, with a current of 12 amperes, means a loss on the leads of 180 volts. An ingenious method of regulation is, therefore, resorted to.



The lamps lighting the station are run off a special transformer, T, the primary coil of which is in parallel with the line. One coil of the "equalising-transformer" E, it will be observed, forms part of the main circuit; while the other coil, which is shunted by an adjustable resistance, is in series with the primary of T. The result of this arrangement, it is obvious, is to cause a diminution of current in the primary of T whenever the current in the main circuit increases, owing to the increase in the back E.M.F. of the shunted coil, caused by the increased mutual induction of the main line and shunted coils. In order, therefore, that the E.M.F. at the terminals A B should remain constant, the difference of potential at the terminals of the dynamo should increase as a function of the output. By suitably arranging the transformer T, the "equaliser" E and the resistance of the rheostat, it is possible between the ordinary limits of working to compensate for the losses on the line by merely keeping the difference of potential between A and B constant. With this object a circuit is interposed between A and B, consisting of a resistance, R, a solenoid, S, and an adjustable resistance, R'. The core of this solenoid is a thin sheet of soft iron, and its motion alters the resistance of the shunt of the exciter M. If the difference of potential between A and B tends to diminish, the resistance of the field-magnet coils of the exciter M is decreased, and the exciting current is consequently

* Abstracted from *l'Electricien*, 12th January.

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augmented, and *vice versâ*. By this means the lamps in each town are kept at their proper E.M.F. whatever the output of the machines may be.

The main conductors are of silicium bronze, uninsulated and run overhead. The Dieulefit line is of 3·2 millimetres wire, the line to Valréas being of greater size, to equalise the resistance. The station is in telephonic communication with either town. The transformers have all a 1,500 watt capacity, and are enclosed in zinc cases fixed to brackets on the walls; their coefficient of transformation is 18, and the E.M.F. at the terminals of the primary being 1,750 volts, the difference of potential at the lamps is 95 volts. At Dieulefit, which is a long straggling town, and where the distance between the first and last lamp is 3 kilometres, the secondaries are all coupled together, with a view to equalise the distribution. At Valréas, on the other hand, which is almost a perfect circle, the secondaries have been arranged in distinct groups, each fed by three transformers. Up to the present everything has been running very well.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 12th*, 1889.

I presume that electrical circles in England are well advised by this time of the sensational exposure which has just been made of the affairs of the Electric Sugar Refining Company, which has its head quarters in this city, and in which a great deal of solid British gold has been invested. If I mistake not you have already given some little space to the affairs of this company, and accurately characterised its remarkable pretensions, but perhaps a few words from this end of the line will not be without interest. The company was formed to develope and utilise a secret process for refining sugar by the use of electricity, and it now appears, as has always been suspected, that electricity has as little to do with the matter as it has with the production of coffee. This process, such as it was, owed its authorship to a chemist by the name of Freund, who, it now appears, was by no means too reputable a person, and who made various efforts in other cities to interest capital before he settled down in New York. The scheme was first brought to the attention of the sugar trade some four years ago, when Freund startled the refiners by announcing that he could take the worst raw sugar and turn it into the best refined at a cost of about 80 cents. a ton. Just how this was to be done he would allow nobody to know, but he exhibited samples of sugars which certainly were superior to the ordinary run, and which he claimed to have been treated electrically. When a desire was expressed to investigate the process exhibitions were given at which the "machinery" was shown covered up with a cloth. As the result of these tests the company was formed, with a capital of a million dollars, and Freund was given 5,250 shares out of the 10,000. Of the remaining shares it is stated that some 300 or 400 were taken up in New York and Philadelphia, while over 3,000 went abroad, most of them being bought up in England, where the greatest interest appears to have been taken in the matter by sugar brokers and refiners. As soon as the company was well organised and in possession of funds, which came from the sale of stock a factory was fitted up over in Brooklyn as a "blind." It was supposed that large quantities of machinery had been put in there, although the exposure which has now been made by breaking into the place reveals little more there than a lot of tables, tin pots and pans, barrels of chemically-refined sugar, and a lot of raw sugar, closely resembling that which from time to time has been carried to the factory for treatment, and has been supposed to have been submitted successfully to the wonderful refining process. Recently, in spite of the death of the inventor, the price of the stock had risen very high, reaching as much as $300 or $400 a share; but a little nervousness was aroused among American stockholders a few days ago, when it was found that the inventor's widow and other members of the family had gone West for parts unknown. The fugitives—for such they seemed to be—were immediately hunted up, and on being discovered and requested to hand over the details of the valuable secret, Mrs. Freund cooly asked whether a process for treating refined sugar would not suit them. This was declined with thanks, and on the news being wired to New York, the mysterious Brooklyn "factory" was broken into, with the result above stated. Shares immediately tumbled to an insignificant value, the whole swindle was made public, and now there is a demand for vengeance on the part of the deluded stockholders here, which is no doubt echoed by the Englishmen who have invested, and who seem to have been worse bitten than anybody else. It is extraordinary that this thing should have gone on so long and that the parties to the swindle should have been able to maintain the deception, and the only inference is that some of those who were in the management, other than the inventor and his family, must have had a pretty good inkling of the true state of affairs. It is some satisfaction to know that electricity had nothing whatever to do with the matter, and that the name "electric refining" was simply assumed for the greater effect it might have on the public. It is a remarkable story of credulity, but no age has been without these examples of blind cupidity, and it may be taken for granted that this is not the last of the series. In fact, there is an analogous case at the present time in the Keely motor, whose supporters have been putting in their hundreds of thousands of dollars for some years past, and who are as far as ever from the knowledge of Keely's secret or any details of the new force of which Keely announces himself as the discoverer. It may be noted, by the way, that Keely, too, now claims to have electricity somewhere in the apparatus. That is an after-thought, and a shrewd one. Still, this sugar-refining *exposé* ought not to be without its lesson for the investors in Keely's stock, and probably we shall hear that it has stirred them up effectually.

I presume that most of your readers have seen notes in the daily papers of the present condition of affairs in Hayti. The inhabitants of that West Indian Island Republic are almost without exception black or brown, and ever since they escaped the yoke of France have done little but squabble among themselves, each autocratic president holding office as long as he had power to do so, and then in turn making room for some less scrupulous and more bloodthirsty successor. The Haytian people, as a rule, are kindly and good natured, but they cannot be said yet to have mastered the science of politics, and hence their history for many years has been a record of internal warfare. At the present time two factions are contending for supremacy, and they are varying the monotony of their otherwise commonplace revolutions by seizing some of our merchant ships. Owing to this fact, there has been great demand and anxiety on the part of the newspapers and people to obtain news from that part of the world, and there has been strong complaint because very little news by cable has been obtainable. The service for the British West Indies has, as you know, been largely carried on by the West Indian and Panama Telegraph Company, which, after a long career, has still to earn the goodwill of the colonists. Latterly a new French cable company has been making connections with the West Indies, but it alleges that it has been blocked by its old competitor and by the Spanish authorities, on the ground that the West Indian and Panama Telegraph Company possesses the monopoly of landing cables in Cuba. The latter company has the support and co-operation of the Local Cuba Company, and the International Ocean Telegraph Company, and the Western Union Company; hence the French company finds itself cut off from communication with the American mainland. This is unfortunate, as the French company touches at the northern part of Hayti, in which the troubles have been the most pronounced, and some of the papers are very severe in their criticisms on the situation, which prevents them from getting early intelligence at such a crisis. Still, I do not exactly see what is going to be done about it. It is hardly likely that the older companies will give up any of their rights or privileges, especially as cable service in the West Indies has not yet, as far as can be learned, been very profitable to the companies interested.

While speaking of cables, I may make a note of the submarine cable which is now being made in this city by the Bishop Gutta Percha Company, one of our oldest manufacturing concerns. It is intended to connect the islands of the Sandwich group in the Pacific Ocean, and is being made according to specifications furnished by Captain Samuel Trott,

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the well-known cable-laying pioneer, now in command of the repairing steamer "Minia," and by Mr. F. B. Hamilton, his electrician. This cable, which is some forty miles in length, is, it may be noted, entirely unarmoured. The stranded copper conductor is first insulated with gutta percha, which is then covered up with soft hempen yarn, saturated with pitch, over which again is a protective jacketing of harder twisted hempen yarn. The cable is weighted and stiffened by being loaded between the layers and threads with a compound of mineral pitch and silica, a heavier coat of which is put on the outside by running the cable through dies prepared for the purpose. The silica is also said to serve the useful end of protecting the cable against the vicious attacks of teredo. It will, perhaps, be remembered by many of your cable readers that Captain Trott has long been an advocate of this species of unarmoured cable, some of which is probably already in use, and it will certainly have an opportunity of showing its efficiency in the deep waters of the Pacific where, if report be true, it is likely to find extended application in some of the plans that are now rapidly maturing for the telegraphic occupancy of that vast stretch of ocean. Our manufacturers have not, up to date, done much in the line of submarine cable manufacture, but this looks like a new departure in that respect, and it is worthy of note that the work should have been given to so old a concern, which, though perhaps not widely known in England, has long had a high reputation here. Bishop cables, I might add, are also in use in connection with the successful work carried out by our light-house board in illuminating the Gedney Channel approach to New York harbour by incandescent lamps.

The big Edison consolidation is now in a fair way of being carried through. The announcement was made this week of the incorporation in New Jersey of the Edison General Electric Company, with a capital stock of $12,000,000, in 120,000 shares of $100 each. This immense organisation is to take over the various Edison manufacturing plants, including the Edison Lamp Factory, the Edison Machine Works at Schenectady, the factory of Bergmann and Company in New York, and the Edison laboratory plant at Orange. The parent Edison Electric Light Company comes into the combination, with all its patents and stock interests in subordinate companies, so that the new corporation starts out with highly valuable assets, and should be in a position to make a fair return from the outset upon the whole of its capital. Specific details of the scheme are still wanting, but the above is the plan in its broad scope and outline. It is said that there will be closer technical affiliations with European concerns, and that on both sides of the Atlantic, especially in Germany, the Edison system will be vigorously pushed. These new arrangements should prove beneficial to Mr. Edison in a financial way, as he has always been a large holder of stock, and there seems no reason to believe that his personal importance, financial or otherwise, will be any less than it always has been.

So far we have been enjoying a remarkably open winter, and the consequence is that electric railway contractors have seized the opportunity to do a little of the work they have in hand. The Bentley-Knight people have been busily engaged preparing Fulton-street, in this city, for the operation of their conduit system. As heretofore employed, this system involved the use of a conduit between the rails of each track; but in the newer and later work, as is exemplified in Boston and here, the conduits are placed not between the rails, but between the tracks. This, of course, is advantageous in allowing for drainage by a single catch-pit and sewer connection, placing the conduits at the crown or highest point of the roadbed, and interfering in the least manner possible with traffic by horses during the period of construction.

The plow which is used in the Bentley-Knight system for contact with the conductor in the conduit is now placed at the side of the car, inside the space occupied by the car step, so that both it and the opening in the conduit slot are covered in such a way as to offer no danger to passengers or obstruction to traffic. Reports from Boston state that a section of conduit on the West End road there has been put into operation, and promises to work well. If the Bentley-Knight system succeeds on Fulton-street it will succeed anywhere.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *January* 22, 1889.

The central station erected by the Continental Edison Company at the Palais Royal was started last Saturday in the presence of the Minister of Public Works and some other important people. The current is distributed to about 2,000 lamps placed in the shops around the gardens of the Palais Royal, but will be shortly extended to the Theatre François, the Theatre du Palais Royal, the Conseil d'Etat and the Cour des Comptes.

The boiler room contains at present five Belleville boilers, and two more will be added later on. The water supply is assured by three large reservoirs, having a total capacity of 158 cubic metres (34,580 gallons). These reservoirs can be supplied from a well by means of a centrifugal pump, driven by an Edison machine, or from the town mains. The smoke is taken along a tube 27 metres in length to the chimney in the Rue de Valois, where the exhaust steam is also discharged. The engine room, which, as your readers will recollect, is under ground in the middle of the main court of the Palais Royal, is 21 metres by 28 metres, and contains the two condensers, the dynamos, engines, and switch-board. At present there are four 150 horse-power Weyher and Richemond engines *in situ*, running at 130 revolutions, and each driving direct on to an 88,000-watt Edison dynamo (110 volts and 800 amperes). There is sufficient room for double this plant. The distributing switch-board is of the same pattern as that in use at the Grand Opera.

The Thomson-Houston system is increasing rapidly in Paris, and in the first fortnight of this month over 200 new arc lamps have been installed at the Theatre des Variétés, the Eden Theatre, the Skating Palace, &c. I have been told that a part of the Boulevards will be lighted during the Exhibition with 200 lamps of this system, and it is certain that this lighting, put up for temporary use, will remain there definitely.

All the firms to which concessions have been granted are rapidly preparing to set at work as soon as possible, and hope to start stations at the opening of the 1889 Exhibition. The time is, however, short, but great efforts are being made by every one, and some will be ready by this time. In the meantime private installations are regularly erected, and scarcely a single day passes without one shop or another replacing gas by electricity. The new light increases in favour also in the provinces. Last Friday the concession for Le Havre was granted to a Paris firm; Bordeaux lights its quais, and Nimes, Marseilles, &c., are engaged in serious negotiations. In one word, electricity gains ground rapidly everywhere in France.

The suit brought by the Société Générale des Téléphones against other French telephone makers for infringement of the patent Edison coil has been decided against the aforesaid company, in spite of a favourable report made by the experts, Potier, Perissé and Co. But the Société Générale des Téléphones will not accept this decision as a final one, and the case will be brought before the Court of Appeal, where this company hopes to be more successful.

NOTES FROM BRUSSELS.

(FROM OUR CORRESPONDENT.)

BRUSSELS, *January* 21, 1889.

The Special Committee appointed by the Conseil Communal of Brussels for the purpose of studying the question of electric lighting met on the 12th inst., and finally decided on its report. This committee, which consists of MM. Bède, Pilloy, Yseux, Depaire, and Wybauw, and is presided over by M. Janssen, advises the authorities to undertake themselves the supply of current for lighting and power purposes. This result was foreshadowed by me in a recent letter, and will, I am afraid, be little to the taste of the electrical syndicate. I trust that we shall not see the great mistake of long concessions repeated; the supply of gas, water and electricity is an attribute of the local authorities, who ought to distribute it in the interests of the inhabitants and not for the benefit of speculators. The question as to whether Belgian firms alone shall be allowed to compete is a secondary matter, so long as no one but the authorities is allowed to fix the price and regulate the conditions of distribution. The Conseil Communal have been well advised—and now to work.

The new installation on the Place Rogier has just been inaugurated. The effect is prettier, but there is not much more light than before.

BRUSSELS, *January* 23, 1889.

The Conseil Communal has occupied itself during its recent sittings with the electric lighting question. The present intention of the authorities is to invite tenders, so that a definite decision can be arrived at within the next month or so. The exact basis

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upon which the tenders will be invited will be settled by the Special Committee, but I think there is little doubt that any system whatsoever will be allowed to compete. A single well-placed station might suffice for all the central portion of Brussels, and if a low-tension system is decided on it will probably be constructed in the north pavilion of the Halles. If, on the other hand, high-tension distribution is employed, the station might well be situated near the gasworks, three kilometres from the Boulevards. In the former case the land would cost 500fr. per square metre, and in the latter only 5fr. the square metre. Amongst the first places to be publicly lighted will be the inner Boulevards, with 120 12-ampere arcs, the park with 80 arcs, and the Theatre Flamand. The security which the contractors will have to deposit will amount to a tenth of the contract price. The tenderers will have to give full details with regard to the power and type of the engines, the method of driving the dynamos, their commercial efficiency, speed, &c. Preference will be given to Belgian machinery, all things being equal.

Now that the question of electric lighting has taken such strides it is interesting to recall some of the earlier efforts which were made in this city. In 1882 the Théâtre de la Monnaie was lit by accumulators, which have since been replaced by the present method, which has proved much more satisfactory. Then, in 1883, the Théâtre du Parc was temporarily lighted by the Edison Company. Since then we have had the Grande Place and the Hôtel de Ville lighted by electricity; the latter installation will shortly be run off accumulators at the Maison du Roi, the cells being charged from the Laeken central station. Private installations also have largely increased, and it is now clearly time for the town authorities to take the matter up.

CORRESPONDENCE.

TELEGRAPHY WITHOUT WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the *Electrician* for November 9th I called attention to a somewhat remarkable disturbance on a short telephone line running between 75, Queen Victoria-street and 59, Knightrider-street, E.C. In your issue for November 16th Mr. F. Higgins suggested that this disturbance might be due to induction from one of his company's exchange telegraph wires; but on making one or two experiments, and hearing the disturbance himself, Mr. Higgins subsequently was satisfied that this was not the correct explanation of the phenomenon.

Through the kindness of Mr. W. H. Preece the whole matter has since been thoroughly investigated by Mr. W. Brown, of the Central Telegraph Office, and I am able to give a *résumé* of the experiments, which may interest some of your readers.

Between 75, Victoria-street, and 59, Knightrider-street, there are two No. 16 B.W.G. hard-drawn copper wires running parallel. The wires are each about 110 yards long, consisting of two spans suspended about 80 feet above the street level. They could be looped or used singly as well, and in the latter case the earth connections were made at each end to either gas or water pipes. There was no disturbance when the wires were looped.

The disturbance was traced as being caused by the working currents in the Postal Telegraph news wire running from the Central Telegraph Office, St. Martin's-le-Grand to Brighton and Portsmouth. The route followed by this wire—which in the City is entirely underground in an iron pipe—is *viâ* St. Paul's Churchyard, across Cannon-street, down Old Change, across Queen Victoria-street, along Upper Thames-street, over Southwark Bridge, and thence to New Cross. No portion of this wire—at any rate on the north side of the Thames—is exactly parallel with the one on which the disturbance is heard, but where the former passes along Upper Thames-street the two are nearly parallel, though from 80 to 100 yards apart.

The Post Office wire is worked with 30 bichromate cells and Wheatstone automatic instruments, the normal speed of working being 350 words per minute, this representing a frequency of 16,800 currents per minute. This circuit was identified as being the one that caused the disturbance by arranging the Wheatstone transmitter to send plain reversed currents and breaking the line connection. When Morse signals were transmitted in this manner they could be read perfectly distinctly on the telephone receiver at 75, Queen Victoria-street, as also at 59, Knightrider-street, the signals so received being similar to the vibrating signals produced with the "buzzer" instrument used for military purposes. Both Bell and Ader telephones were used as receivers, the latter giving the loudest and most distinct results.

After the disturbing circuit had been thus identified, several experiments were tried to determine in what way the interference took place. The earth connection of the Wheatstone transmitter at the Central Telegraph Office was removed, and wires earthed at Clapham Junction and at London Bridge in turn substituted, without having any appreciable effect on the disturbance. On the section of the disturbing circuit between St. Paul's Churchyard and Thames-street being changed, and a fresh wire in the same pipe substituted, the interference was still felt, but was to some extent reduced, probably by one-fourth.

Another wire which runs underground *viâ* Cannon-street was next substituted for the one *viâ* Thames-street. The disturbance was still heard, but was reduced in volume by about one-half. A wire *viâ* the north side of Cheapside was next experimented upon, it being substituted for those through Thames-street and Cannon-street previously tried. The interference was now reduced to about one third of the normal, but it was still quite easy to read the signals. After this a spare wire was earthed at the junction of Thames-street and Queen Victoria-street. This wire runs from the Telegraph Office in the same pipe as the original disturbing wire, and was substituted for the earth at the central telegraph office on the Wheatstone instrument. When this loop was used the interference was considerably increased in loudness, from which it appeared that the loop wire was not earthed far enough away. The spare wire was therefore extended in the same pipe as the disturbing wire as far as the Old Kent-road, and there earthed. Upon again substituting this spare wire for the earth of the Wheatstone instrument the interference was practically neutralised, being reduced so as to be only just audible above the general disturbances which affect the wires. No doubt had the two wires been twisted, absolute silence, so far as the disturbance due to the Wheatstone instrument was concerned, would have been obtained.

These experiments seem to prove conclusively that the disturbance is due to induction pure and simple. The fact that when the Wheatstone instrument was earthed at Clapham the disturbance was in no wise diminished shows that it can scarcely be a matter of earth leakage. It would, however, be interesting to know whether the effect is simply a case of direct induction through space between wire and wire, or whether the earth in some more or less secondary capacity has any thing at all to do with it.

It cannot be claimed that the above results are novel, as they only bear out those previously obtained by Mr. Preece in the Severn Valley and elsewhere, and described by him in 1887 at the British Association meeting at Manchester; but still it will, I believe, surprise not a few that the electric currents in a wire laid underground in an iron pipe passing along Cheapside should so influence surrounding space that, no matter the buildings in the way, a telephone connected to another wire only 110 yards in length, suspended 80 feet above the level of the ground, and nearly 300 yards distant, should faithfully and loudly repeat every electrical impulse.

That a current only a few milliamperes should affect all space within a radius of at least 300 yards to an extent capable of appreciation by human senses is certainly a wonderful instance of the natural transmission of power; but perhaps when we come to remember the enormous distances through which luminous radiations—probably electro-magnetic in their nature—are propagated without sensible loss through space, we shall recognise that it is merely because the former phenomenon is more unfamiliar than the latter that we think it more remarkable.

Apologising for trespassing at such length on your valuable space.—Yours, &c.,

66, Victoria-street, S.W., January 21, 1889. A. A. CAMPBELL SWINTON.

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MR. EDMUNDS' METHOD OF MAINTAINING CONSTANT CURRENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the letter of Mr. Bate on the above subject, I would say that I did not intentionally ignore the remarks of Mr. Preece or himself in my reply to the discussion; for the allusion to this mode of obtaining constant current was rather an incident than otherwise in my Paper on "Electrical Distribution," and I did not wish at that time to give it the prominence which it deserves, only desiring to indicate that I was working in this line, rather than to enter into full details in connection with it.

I, however, take this opportunity of saying that I first observed that constant-current machines would automatically speed themselves if they had a constant pressure of steam, during the early work I did in lighting the Liverpool-street Station by the Farmer-Wallace system in the winter of 1878. We there employed a Robey steam engine, and I was not a little surprised to find on one occasion that when the governor belt broke the engine did not run away, but maintained a given speed with the then given load of, I believe, six arc lights. One of the arc lights happened, through some derangement, to short-circuit itself, which was immediately attended by a lowering of the speed of the engine, without any alteration of the valve by the engineer in charge. Though I made this observation so long ago, it did not occur to me until more recently to apply it practically, from the fact that we did not get steady motion with comparatively slow-speed engines, such as were then used, and, further, in most of the then installations a uniform speed in the engines was a necessity, and elaborate governors of all kinds were brought forward for this purpose. Many of the engines were expected to drive other work beside the dynamo, and some to drive two or more dynamos, so that it was better to have a constant speed than a variable one. In order to do this, I suggested to Mr. Richardson, of the Robey Company, that a governor might be made that should automatically control the steam admitted to the engine, by variations in the current, thereby effecting a mode of regulation in the same way as the Richardson and Willans governors. But with ordinary constant-speed engines regulators have been devised by constant-current dynamo constructors, such as Thomson-Houston, Brush, and Hochhausen, in which they avail themselves of a constant-speed engine and dynamo, keeping the current constant, but varying the E.M.F. in accordance with the variations of the work by their several methods of varying the adjustment of the brushes and the regulation of the exciting field, such regulations being attended by the variation of the supply of steam by the automatic governor of the engine; but I believe that I can show that these elaborate regulations are not necessary.

When I had an opportunity, such as presented itself at the Cadogan station, of employing a fairly large dynamo of, say, 28,000 watts, requiring a constant current with a variable potential, and having also such an excellent engine as the Armington-Sims, which can be run at high rates of speed, maintaining meanwhile a full passage through the ports, I thought it was a good opportunity for putting into practice my observations of ten years ago, and to employ several individual engines, each running separate dynamos, rather than put all the work on to one engine with one large dynamo or several small ones. The apparent paradox as to why a machine doing less work should run at a less speed generally presents itself as a difficulty to anyone looking at this question for the first time, but I think it is not difficult to explain this satisfactorily if we look at the question in another light. I would ask Mr. Bate to imagine the following conditions, very similar to those we have in practice at the Cadogan station, and cite the example he gives in his own letter: "The engine, the starting valve of which has been opened, so that it drives the dynamo just fast enough to generate 70 amperes at, say, 10 volts [or, better expressed, say "fast enough to generate 10 volts by 70 amperes"] = 700 watts, say 1 brake horse-power—will, without attention to anything except the maintenance of a constant steam pressure of 70 pounds on the boiler, and without alteration to the starting valve, increase its speed until it gives 70 amperes at 2,000 volts = 140,000 watts, or, say, 200 brake horse-power." The only difficulty in his proposition is a mechanical one. I should not care to run either the dynamo or the engine at the speed required to give off this energy, but there is no electrical reason why it should not be done. Let us, however, follow his illustration up to 500 volts, which we see might mean the dynamo running at 1,000 revolutions (that is, two revolutions per volt), and I will now ask him to follow me in the subjoined remarks.

70 amperes by 10 volts may be taken as 20 revolutions of the dynamo. We will say that the engine is speeded proportionately—that is to say, at a third of the dynamo speed. It would then be going at about six revolutions. This would be in the condition that Mr. Kapp very properly objected to, but this objection is overcome by the fact that the machines are never worked with a less external resistance than one ohm or say a line of two miles of $\frac{3}{8}$-inch conductor. One ohm, resistance to 70 amperes on such a line would represent 70 volts, or 140 revolutions of the dynamo, or 46 of the engine. This is practically the minimum speed. Now, why does the engine with full valve not run away? That is the question, and the answer is that 70 pounds of steam cannot generate more than 70 amperes of current under the proportions of the area of the piston and speed considered. Supposing, however, that more work is put on so that the external resistance is doubled. It will be observed that, at the moment when this extra resistance is put in, the dynamo is running at 140 revolutions, giving 70 volts by 70 amperes, through 1 ohm; but it suddenly meets with 2 ohms resistance, and the E.M.F. accordingly rises to 140 volts, and the current falls to 35 amperes. This practically liberates the engine, which was held back by 70 amperes; and it commences to speed up—that is, provided the port ways are open and there is a good head of steam—until the dynamo again comes up to the resistance, to 70 amperes, which again acts like a brake on the engine, and the speed of the dynamo becomes 280 and the engine about 93. We increase the work further, either by the addition of more line resistance or more battery resistance, and every increase of resistance placed in the line causes the dynamo to lower its current value, which is immediately attended by the speeding up of the engine, until it reaches the mechanical limits of speed at which we deem it desirable for the dynamo and engine to run—say, a maximum speed for the dynamo of 1,000 revolutions, and the engine about 333. Now, if Mr. Bate takes these figures at this point he will find that we have 1,000 revolutions, 500 volts, 70 amperes, and 50 horse-power, which he will see is proportionate in each case.

Let us now reverse the operation, and cut down the external resistance. We will find that when the resistance is cut down one half the result will immediately be that, with this speed and E.M.F., the current will have the effect of a brake on the engine, and reduce the speed; not because we turned off the steam, but because we gave it more work than that pressure could overcome. But as the engine slows down so the voltage diminishes, and it is found in practice that when the engine slows down and the E.M.F. falls until the current is again 70 amperes, it will have just slowed down to half of what it was previously, viz., 500 revolutions of the dynamo, with 70 amperes of current, with an engine-speed of 166. Let us again halve this, and we find the same rule applies, until at length we can literally short-circuit the dynamo through one-seventh of an ohm resistance, which would require only 10 volts, coming back to where we started; and I maintain that, with these conditions, it is not necessary to resort to the complex arrangements alluded to by Mr. Bate.

It is also interesting to note that we have an indication of the measure of the work at any time under these conditions by simply reading the number of revolutions from a tachometer on our dynamo, first noting that the steam pressure is 70 on the boiler.—Yours, &c.,

HENRY EDMUNDS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, Mr. Bate, takes exception in your last issue to Mr. Edmunds' statement that an engine driving a separately-excited dynamo will, without a governor, adapt itself to the work it has to do in maintaining a constant current,

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whatever may be the resistance in the external circuit. It appears to me that, *within limits*, Mr. Edmunds' statement is quite correct. The conditions I think, however, are hardly sufficiently strict. I should be inclined to say that one condition was that the passage from the boiler to the engine cylinder should be very free and unobstructed, so that the pressure on the piston may be practically always the same at whatever speed the piston is running. Were it not that this condition is difficult to secure in practice for large variations in speed, and that it requires that the engine itself should be carefully proportioned to the dynamo and current, and also that the friction of bearings, &c., produce different effects at different speeds, it would be a simple matter. It is clear that if the pressure in the rear of the piston is in excess of the resistance to its movement offered by the torque of the dynamo and other resistances transmitted through the piston rod, the piston will accelerate its speed until the E.M.F. of the dynamo and, consequently, its current and torque, increase sufficiently to balance the pressure on the piston. If now the resistance in the external circuit be increased, the current will diminish, and with it the torque; the engine will thereon accelerate its speed until the current has pretty well reached the normal amount. In practice, however, it would, I think, be found that, principally owing to the loss of steam pressure by friction in the passages, which would obviously increase as the quantity of steam passed per minute increased, the current would fall somewhat as higher E.M.F.s and speeds became necessary, and that unless an electrical governor were used it would be necessary to have a certain proportion of shunt wire on the field-magnets to compensate for the engine running somewhat slower than theoretically it ought to do.

With respect to the question why is it necessary to use a separately excited dynamo, I should be inclined to agree with your correspondent that it is not necessary, and that a series-wound machine should give the same result, the only point occurring to me with respect to this being that some "hunting" effects might come in, owing to the magnetisation of the magnets varying as resistances were inserted and taken out in the external circuit. With respect to his last paragraph, I think your correspondent has hardly appreciated the fact that one of the main objects of most builders of engines is to drive them at the greatest speed to which they can be worked without flying to pieces by centrifugal force or knocking themselves to pieces under the influence of reciprocative action, and that a large proportion of the improvements in modern machinery have for their object the safe driving of engines at higher and higher piston speeds.—Yours, &c., R. H. C. Neville.

Wellingore Hall, Grantham, January, 21, 1889.

REFUSE DESTRUCTORS AND THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your paper of January 11th you refer in somewhat flattering terms to a scheme for using the town refuse for driving an electric light installation for Derby. The quality of town refuse varies greatly in different towns, depending somewhat on the price and quality of the coal used in the neighbourhood. In the case of the 150 tons referred to, all the dust is supposed to be taken out, but that being done you only assume it to be of one-third the value of steam coal for steam-raising purposes. This I consider very low indeed for such fuel as there is here; but even at this low rate you get a result of 220 horse-power continuously, or 440 horse-power 12 hours per day, whereas in a recent Paper of mine I set down 450 horse-power 15 hours per day. I enclose you a copy of my Paper. It is now over four years since I first mentioned this scheme to the late T. Coulthurst, Esq., borough engineer for Derby, and the matter obtained very little notice until I again introduced the question about six months ago, and I am pleased to say to all appearances with better results. You, however, will scarcely believe that nine months ago I sent a copy of this scheme to a local authority in the South of England, who wished to use up their refuse for electric lighting purposes, but they did not as much as acknowledge my communication. I must thank you for the notice you have taken of my scheme, and beg leave to say my only object is to prevent the waste at present going on in burning good fuel simply to get it out of the way; there is no monetary reward in this scheme, there being no patents or royalties connected with it, so I cannot be termed an interested party in a monetary sense.—Yours, &c.

F. W. Brookman, Refuse Destructor Foreman.

THE PHYSIOLOGICAL EFFECTS OF ALTERNATING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Your American letters have latterly said a good deal about the relative danger of alternating and direct currents employed in electric lighting. Nobody cares to let their own body be the arbiter in this dispute, and I do not pretend to say that the trial I have made myself is conclusive on the point; but for what it is worth I will describe it, especially as the instrument referred to is plentiful in this country, and little used in America. The experiment is as follows:—Attach two wires (with suitable holders for the hands) to a Wheatstone automatic transmitter. If the hands are in a normal condition of moisture the experimenter will be able to retain his grasp of the holders at a very high speed without any alarming symptoms. The first shock at starting is probably the hardest to bear. A strong man, not troubled with nerves, will bear the rapidly alternating currents at full speed. What relation this bears to the speed of an alternating current dynamo I do not pretend to say; but my general impression after repeated trials with the Wheatstone transmitter is that its current becomes alarming only when the speed reaches a point when the centre of the body—not the arms alone—experiences the sensation, and when the nervous conviction arises that the experimenter will not be able to leave go the holders if he tries, which is generally the case. But now comes the curious fact: If the instrument is gradually *slowed*, the shocks become painful, until at length they are quite unbearable. I do not say they frighten the patient as much as the very rapid currents; I am only speaking of physical effects; and I say emphatically that while the high-speed currents can be borne when the experimenter is not in a funk, *the slow currents cannot*. Or to put it differently, the slow currents give a great deal more physical pain than the rapid currents. Of course it follows that a single powerful shock has far greater effect on the sensation than the same current rapidly alternated. It does not perhaps necessarily follow that a death-dealing current would be rendered harmless by being made alternating; but if the relative *pain* caused by the two kinds of shocks be any criterion of their probable effect on life, it would seem to follow that an alternating current is the least fatal. Telegraphist.

London, January 22, 1889.

ALKALINE ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In Mr. Elwell's remarks on the above subject in your issue of the 18th inst., I notice that he mentions that the zinc is deposited on iron gauze. May I be allowed to ask how long such an accumulator will hold its charge, since zinc is dissolved in alkaline solutions when in contact with iron? This fact appears to be of great importance, especially when the battery is used, as the writer suggests, for miners' lamps, or in any case where the discharge is spread over a long period.—Yours, &c.,

London, January 23, 1889. A. E. Greville.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In his article on "Alkaline Accumulators," in your last issue, Mr. P. B. Elwell describes a portable combination in which a negative of compressed silver powder, with a zinc positive in an alkaline electrolyte, is used. Now such a combination has been employed by me for some considerable time, dating so far back as 1881, and should confirmatory testimony be needed it could readily be produced, as batteries made on this principle, both primary and secondary, were made and sold by the firm I was at that time connected with. Of course I do not say that my method of working is identical with that described by Mr. Elwell in all

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details; as is to be expected the methods differ somewhat in detail of construction (for instance, I use an amalgamated zinc plate simply, his friends iron gauze upon which zinc is deposited; I support the compressed silver powder on a thin plate of silver, usually foil, but they have succeeded in making the compressed powder self-supporting), but I think I have said sufficient to show that I am entitled to put on record the fact that I have been working on very similar lines to Messrs. Dezmazures and Commelin for a considerable time. I am still the more desirous that such fact should be recorded, as, should I (or my friends) be disposed to make further use of my method of working, the risk of being accused of copying the alkaline accumulator of Messrs. Dezmazures and Commelin will thereby be prevented.—Yours, &c.,

January 23, 1889. H. J. COATES.

BATH ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should not have troubled to reply to the letter of the secretary of the above company had he confined himself to facts; but he tries to mislead your readers by what I can only describe as a perversion of the truth. He asserts that the Bath Corporation have "somewhat reluctantly" concluded a contract with me, &c. The exact contrary is the case. At my suggestion the Corporation decided to entertain lighting all the principal thoroughfares with arc lamps, and grant facilities for the supply of private lighting. This question has been under their consideration for more than twelve months. Advertisements for tenders appeared for two successive weeks in each of the electrical journals; each contractor was required to tender for overhead and underground mains. Ten tenders were received, of which the one sent in by myself (on behalf of a local supply company) being the lowest, for both overhead and underground mains, was accepted. All those who had taken the trouble to make themselves acquainted with the peculiar difficulties in the way of running underground in this city recommended overhead wires, and the majority of the Corporation being of the same opinion, that method was adopted. At the meeting when the final vote was taken of a Council numbering fifty-four members, only one gentleman voted against the contract being signed.

Considering that gas for the public lamps is charged only 1s. 11d. per thousand in Bath, the well wishers of electric lighting throughout the country were surprised at the almost unanimous vote of the Council. In common with others, the House-to-House Company had the opportunity of tendering, but it does not appear to have answered their purpose to enter the field of fair and open competition.

The following report of what took place when the application of the House-to-House Company was read shows the feeling of the members of the Bath Council:—

Mr. Cox said that was an application for another company to go in and do the work which another company was engaged to do, and before they knew how it was to be done. They were in a transition state at present, and no interference should be allowed.—The Chairman: How can we, after arranging with one company, entertain proposals from another?—Mr. Sturges: We would not be allowed.—The Chairman: Well, I do not think so.—Mr. Mitchell then moved, and Mr. Sturges seconded, that the matter be referred to the Electric Light Committee. This was unanimously agreed to.

The opponents of electric lighting in Bath are delighted at the "dog in the manger" policy of the House-to-House Company, but the friends of electricity naturally regret it. The insinuation of the secretary of the House-to-House Company to the effect that they possess the most perfect installation yet constructed, and are the only people capable of undertaking central station work, may be correct, or it may be their opinion only. In any case I prefer to employ firms of standing and repute, who have already given me unqualified satisfaction, but whose names I purposely withhold, as I do not wish to make your correspondence columns a means of advertising any particular firm or company. The secretary of the House-to-House, in true imitation of the Maxim-Weston Company in its worst days, refers to my calling in terms neither true nor complimentary. I am usually described as a boot and shoe manufacturer and leather merchant, but this gentleman very politely designates me a "boot and shoe maker."

During the past four years my association with the electric lighting industry has been of a most agreeable character, and all professional electrical engineers with whom I have come in contact have been honourable business men, and gentlemen, but the promoters of the House-to-House Company appear to be exceptions to this rule.—Yours, &c.,

H. G. MASSINGHAM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Shylock may have been legally entitled to his pound of flesh, and rival companies may be legally entitled to engage in cut-throat and disastrous competition; but the question as to what is fair and just also deserves consideration.

I think the electrical profession will in general agree with me that the action of the so-called "House-to-House Electric Light Supply Company at Bath is calculated to have a prejudicial effect on, and is antagonistic to, the progress of provincial electric lighting.

It would be interesting to learn how many thousand lamps are at present being supplied from the central station, "which is by general admission the most perfect of its kind," and the mileage of underground mains connected therewith.

I am personally unacquainted with Mr. Massingham, and in this case simply, Yours, &c.,

A DISINTERESTED OBSERVER.

Liverpool, 21st January, 1889.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The thanks of every true friend of electric lighting progress are due to you for the well-merited rebuke contained in your editorial note appended to a letter appearing over the signature of H. St. John Winkworth in your last issue. That the tactics of the now happily defunct Maxim-Weston Company, as directed by Mr. Watt, should be again revived would be an eventuality against which the best efforts of every member of the electrical engineering community, backed up by the whole power of the scientific press, could not be better than employed.

It is not the energetic prosecution of legitimate business which is to be complained of, and no firm with a reputation to keep up objects to open competition, but the underhand system which certain so-called and self-styled pioneers of electric lighting adopt, of waiting until a contract is either absolutely signed or on the point of signature, the burden and heat of the day having been borne by others, and then, and not till then, stepping forward to reap the harvest, if possible, but, any way, to turn the other man out, even if total abandonment of the project should follow.

Granting, for the sake of argument, that the engineers of the House-to-House Company have laid out a station with underground mains, what right has Mr. Winkworth to trumpet forth the achievement as the *only* central station so arranged? Is he such a late acquisition (?)—save the mark—to electric lighting ranks that he has never heard of the Edison station in New York, besides others of later date at Chicago and elsewhere, both on that and other systems; or, to come nearer home, has he never heard of the Kensington Court, Metropolitan Electric Supply, Chelsea Electricity Supply, and others, all using underground mains?

Although Mr. Winkworth may not be aware of it, electric lighting with underground mains has been going on for some years now—going on successfully, too—and some of us, having been "in it" from the first, can afford to smile at the cry of "only show in the fair" which the fresh men make.

Not wishing to get a free advertisement for myself out of you, Mr. Editor, I beg to sign myself—Yours, &c.,

MARSDEN.

"ETHER."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly permit me to offer a few remarks upon the leading article in your impression of the 18th inst.?

Somewhat startled at the statement therein made that "the pressure of ether per square inch (under, or rather within, which

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we live and move and have our being) must be about seventeen billions of pounds," I made a rough calculation, based upon the well-known law of the relation between wave-propagation, density, and elasticity. Taking the velocity of sound in air as 1,100 feet per second, and the velocity of the waves of radiant energy in ether as 192,000 miles per second, the ratio for the two media is approximately one million. Now, according to this law, for media of equal density the elasticities are directly proportional to the squares of the velocities of wave-propagation. Whence, for ether *with the same density as air on the earth's surface*, the electric force would be fifteen billions of pounds. Applying corrections for modifying influences on sound velocity in air, it is probable that the result given in your article, viz., seventeen billion pounds, would be obtained. But, fortunately for us, we do not live and move and have our being in ether so dense!

The value given in the earlier part of your article for the inferior limit to ether density in planetary space enables one to calculate the minimum elastic pressure exerted by the ether in that region.

This value is of course vastly below 17×10^{12}lb. per square inch. But even supposing the ether at its actual density to exert such an enormous pressure, one fails to see in what way this would modify one's belief in its existence. Having in view the "open structure" of matter, even of the ultimate atoms, two things are evident.

Firstly, that an excessively small fraction of the structure of any portion of matter is subjected to ether pressure. Secondly, that this pressure, being interatomic, as well as intermolecular (that is to say, exerted within and all around in equal amounts) no change in the chemical, physical, or dynamical condition of the body could be produced by it.—Yours, &c.,

The School of Electrical Engineering, E. T. CARTER.
Hanover-square, W., Jan. 23, 1889.

"THE TELEPHONE," BY PREECE AND MAIER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would you kindly grant me space to correct an error which appears in this book. In the part treating of automatic cash boxes for public call offices the one described and illustrated at page 371 is stated to have been introduced into Manchester, whereas having been invented by Mr. Sinclair, engineer to the National Telephone Company (Limited), Glasgow, it was introduced, and is now much used, in that city and West of Scotland.—Yours, &c, J. M. Jun.

BOOKS, &c., RECEIVED.

The *Journal* of the Iron and Steel Institute. No. 2. 1888. (London: E. and F. N. Spon.)

"Annuaire pour l'An 1889. (Paris: Gauthier-Villars et Fils.)

PATENT RECORD.

APPLICATIONS FOR PATENTS.

18,319. W. S. BOULT. London. Improvements in or relating to suspenders for shades or lamps, especially applicable to electric lamps. December 15, 1888.

18,331. H. P. HOLT. Manchester. Improvements in electro-dynamic engines for hauling or propelling vehicles on railways and tramways. December 15, 1888.

18,416. M. J. R. JACQUEMIER. London. Improvements in apparatus for measuring currents of electricity. December 17, 1888.

18,450. J. Y. JOHNSON. London. Improvements in dynamo-electric machines and electric motors (C. S. Bradley, United States). December 18, 1888.

18,494. J. L. ROBERTS and H. L. BREVOORT. London. Improvements in galvanic batteries and in the arts. December 18, 1888.

18,500. B. VERITY and J. B. VERITY. London. Improvements in means or apparatus for use in laying or conveying underground electrical conductors. December 18, 1888.

18,505. H. B. SHERIDAN. London. Improvements in electrical torches for lighting gas J. D. Culp, United States). December 18, 1888.

18,525. E. WILSON. London. Improvements in alternate-current motors. December 18, 1888.

18,526. J. C. L. LOEFFLER. London. Improvements in submarine telegraphic cables. December 18, 1888.

18,589. J. L. HUBER. London. Improvements relating to secondary batteries. December 19. 1888.

18,636. J. C. FULLER and G. FULLER. London. Improvements in electrical accumulators. December 20. 1888.

18,659. SIEMENS BROTHERS AND CO. LIMITED. London. An improvement in electric motors worked by alternating currents A. M. Taylor, India. December 20, 1888.

18,660. E. MARTIN. London. An improved manufacture of wire coated with copper or other metal for electrical conductors and other purposes. December 20. 1888.

18,677. L. B. BETHELL. Winchester. An electric switch. December 21, 1888.

18,679. L. B. BETHELL. Winchester. A self-acting electric thermometer fire alarm, or temperature indicator, and atmospheric change indicator. December 21, 1888.

18,712. C. WELLS. London. Improvements in electric locks, bolts, and the like. December 21, 1888.

18,715. F. J. SMITH. London. Improvements in or connected with telephones, speaking tubes, stethoscopes, phonographs, and other instruments through which sound waves pass. December 21, 1888.

18,718. C. E. J. MAY. London. An improvement in tubular posts for telegraphic and other purposes. December 21. 1888.

18,727. R. P. SELLON and C. WATSON. London. Improvements in electric continuous-current transformers. December 22, 1888.

18,747. H. A. GOAROFF. London. An arc lamp regulator for electric lighting. December 22. 1888.

18,754. G. C. DYMOND. Liverpool. Improvements in or relating to galvanic batteries C. Gassner, Germany). December 22. 1888.

18,763. C. B. BURDON. Liverpool. Improvements in apparatus for detecting the presence and direction of currents of electricity. December 22. 1888.

18,784. W. F. LAHMEYER. London. Method of and means for regulating electric currents, dynamo machines and electric motors. December 22. 1888.

18,797. S. SCHUCKERT. London. Improved electrical signalling apparatus. December 22. 1888.

18,807. T. PARKER. Manchester. Improvements in the method of and means for producing intermittent electric currents. December 24, 1888.

18,812. R. F. YORKE. Haywards Heath. Improved method and apparatus for the distribution of electricity by means of alternating currents of electricity in conjunction with electrical storage. December 24, 1888.

COMPLETE SPECIFICATIONS ACCEPTED

NOTE.—*All persons interested in opposing the grant of a patent on any one of the undermentioned applications may, at any time within two months from the date in italics, give notice at the Patent Office in the prescribed form of such opposition.*

December 22, 1888.

17,209. J. WILLING (the younger) and A. D. DOUGLASS. London. A combined switch and electric lamp support for public and private conveyances. December 14. 1887.

1,091. D. A. AIRD. London. An improvement in or connected with counting or recording mechanism released electrically. January 24, 1888.

1,254. J. SPINK and C. GAUZENTES. Bradford. Improvements in forming metallic connections with incandescent electric lamps, and holders therefor. January 27, 1888.

1,919. A. J. HOWES. London. An improvement in arc electric lamps. February 8, 1888.

2,073. A. C. IWANOWSKI. London. An improved electric alarm apparatus. February 11, 1888.

2,251. A. GRAHAM. London. Improvements in switches for electric circuits. February 14, 1888.

2,368. M. BAILEY and J. WARNER. London. An improved method of manufacturing woven plates for secondary batteries. February 16, 1888.

2,438. R. LANGHANS. London. Improvements in the manufacture of illuminating conductors for incandescent electric lamps. February 18, 1888.

2,450. W. HIBBERT. London. Improvements in electrical measuring instruments. February 18, 1888.

8,950. C. B. BURDON. London. Improvements in applying electrical traction to pleasure, sporting, and business purposes. June 19, 1888.

10,604. J. A. TEMMIS. London. Improvements in the elements for secondary batteries. July 21, 1888.

11,082. P. A. NEWTON. London. An improved mode of and apparatus for transmitting and recording electrically autographic messages, signals, and marking (E. Gray, United States). July 31, 1888.

16,099. C. M. DORMAN and R. A. SMITH. Manchester. Improvements in the construction of electrical switches, cut-outs, ceilings and wall connectors. November 7, 1888.

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PATENTS SEALED.

December 21, 1888.

14,632. J. A. TIMMIS. London. Improvements in electrically lighting railway trains. October 27, 1887.

15,161. P. EVERITT. London. A coin-freed electrical current-producing apparatus. November 7, 1887.

15,735. W. R. LAKE. London. Improvements in electrical indicating or signalling apparatus (C. Grivolas fils, France). November 16, 1887.

16,324. F. T. SCHMIDT. Bradford. Improvements in electro-mechanical striking gongs. November 28, 1887.

16,870. R. TATHAM. Rochdale. Improvements in electro-dynamic generators and motors. December 8, 1887.

17,031. W. LAHMEYER. Brussels. Improvements in or relating to the regulation of electric currents and in apparatus therefor. December 10, 1887.

17,409. C. A. MCEVOY. London. Improvements in electrical primers or fuses. December 17, 1887.

729. D. URQUHART. London. Improvements in electric batteries and elements therefor. January 17, 1888.

12,437. W. A. CONNER and J. W. MARSH. United States. Improvements in electrical conductors or cables. August 29, 1888.

13,128. J. IRWIN. United States. Improvements in electric railway signalling systems. September 11, 1888.

13,193. E. M. H. ANDREOLI. London. Bleaching paper pulp by electrolysis. September 12, 1888.

SPECIFICATIONS PUBLISHED.

17,133, 1887. COURTENAY, R. H. Generating and converting electric currents. (Price 8d.)

17,415, 1887. LORRAIN, J. G. Electrical measuring and recording apparatus. (Price 8d.)

17,966, 1887. RHODES, O. Y. Electric batteries, &c. (Price 8d.)

1,875, 1888. HOOKHAM, G., and HOUSMAN, R. H. Dynamo-electric machines, &c. (Price 8d.)

1,891, 1888. BAILEY, M., and WARNER, J. Flexible battery cell, &c. (Price 8d.)

3,312, 1888. TYER, E. Voltaic batteries. (Price 8d.)

14,934, 1888. HUTCHINSON, R. R. Rotating hydro-extractors by electricity, &c. (Price 8d.)

16,146, 1888. MORETON, F. Electro-medical batteries. (Price 8d.)

242, 1888. DAVIES. Electrical measuring instruments. (Price 8d.)

366, 1888. ABEL (Siemens and Halske). Electric arc lamps. (Price 8d.)

1,525, 1888. SOLIGNAC. Distributing electricity. (Price 8d.)

2,449, 1888. ALLEN. Electric railways. (Price 8d.)

13,529, 1888. RECKENZAUN. Electric meters. (Price 8d.)

14,979, 1888. HUTCHINSON. Electric brake, &c. (Price 8d.)

17,726, 1887. STATTER, J. G. Electro-motors. (Price 6d.)

1,213, 1888. LEIGHTON, J. T. Applying electricity to spectacle frames. (Price 8d.)

1,383, 1888. BOREL, F., and PACCAUD, E. Electro-motor or electric current meter. (Price 11d.)

11,065, 1888. THOMPSON, W. P. (Westinghouse). Electric lamps. (Price 6d.)

11,681, 1888. LIEBERT, C. E., and ROSENTHAL, S. A. Electric batteries. (Price 6d.)

15,388, 1888. SHIPPEY, A. (Waterhouse). Regulating dynamo-electric machines. (Price 8d.)

15,612, 1888. LOVE, J. C. Insulators for electrical conductors. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Eastern Telegraph Company (Limited).

The thirty-third half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held yesterday (Thursday), the 24th inst., at Winchester House, 50, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. Draper) read the notice calling the meeting, and the minutes of the last meeting were confirmed. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I will, as usual, give you some fuller details respecting the Company's working than are contained in the report. Our revenue for the six months ended September, 1888, amounted to £310,104, as against £291,265 in the corresponding half year of 1887, showing an increase of £18,839. The chief item of increase is from our holding of shares in the Eastern and South African Telegraph Company, the dividend on which is at the rate of 12 per cent. per annum, as against 8 per cent. per annum in the corresponding period of 1887, showing an increase of £7,800; the return for the half year from our investment in the Black Sea Telegraph Company is increased by £1,393; our Direct Spanish Shares have yielded an additional £307, interest gives us an extra £600, transfer fees £13, and our general traffic, chiefly South African and South American, £10,531. That makes a total of £20,644; but we have ceased to bring into our revenue accounts the dividend on Direct Spanish Company's Debentures, which are now considered as an investment for our reserve fund, so we must deduct £1,805, leaving the total increase at £18,839. The total working expenses for the half year amounted to £83,332, against £79,936, or an increase of £3,396. The details of increase and decrease are as follows:—General expenses in London, £7,845, against £8,012, or a decrease of £167. Working expenses at stations, £59,962, against £56,386, being an increase of £3,576. This is principally caused by the number of foreign staff having been increased to work the triplicate cable from Porthcurnow to Malta and extension to Zante, also the duplexing of same. We have also opened a new station at Cadiz, having put that place in telegraphic connection with Villa Real and Gibraltar. The laying of the new cable from Porthcurnow to Malta and Zante, besides giving us greater security and rapidity of working, has diverted to our system a large part of the Greek and Turkish traffic which formerly went *viâ* the Continent. The foregoing explanations also account in a great measure for the increase in travelling expenses, rent, stationery, and maintenance of instruments. A greater number of messages have been carried this half year than in the corresponding period, and the work to be performed by our staff increases year by year. £1,000 of the total increase in the working expenses is explained by our having carried £5,000 to our reserve fund for maintenance of ships, against £4,000 last half year. The repairs to cables amounted to £43,075, against £34,102, or an increase of £8,973. This is always an uncertain item in our accounts. Our ships have been busily employed in maintaining our system in a state of efficiency. The increase under this head is in the value of the new cable laid in, the total length being 130 miles against 38 miles in the corresponding half year of 1887. You will find on reference to the reserve fund that we have applied over £13,000 in reduction of capital expenditure, or, in other words, although we have spent over £13,000 in extending and improving our system, the capital expenditure remains at practically the same figure as last time. The Six per Cent. Debentures of the Direct Spanish Telegraph Company have been transferred to our reserve fund investments, which stand at £315,494, and our total reserves, after deductions, at £355,676. We pay the usual interim dividend at the rate of 5 per cent. per annum, and after providing for interest on Debentures, Debenture Stock and Preference Shares, we are able to carry £36,616 forward to our next account, against £29,397, or, £7,219 more than in the corresponding period of 1887. The Chairman afterwards reminded them of the full history which he gave of the Company at the last meeting, and stated that all the new Ordinary Shares had been fully taken up. The work of the South African Company's extensions was in hand, and he believed that at their next meeting, six months hence, he would be able to state that they had completed their West Coast of Africa cable—a work which would not be completed an hour too soon. The enormous traffic now going on to the Cape and the Transvaal, owing to the gold speculations, brought a great deal of grist to the Company's mill. With the completion of the cable mentioned, he believed that the Company would be able to meet all the telegraphic requirements of the public. Their system was working thoroughly well, but to maintain it in a complete state of efficiency—which they considered of vital importance to the welfare of the Company—their ships were kept fully employed; and he might add that, being in the neighbourhood of Suakin, they had given every possible assistance to the English Government while the Egyptian and British troops were in action there. This assistance had been greatly appreciated (cheers). Had they not duplicated their system and applied the duplex, they could not possibly have carried out the work they had done. The world could not live without the telegraph system, and they must see to it that they maintained their system in a condition of thorough efficiency. He concluded by moving the adoption of the report and accounts.

The MARQUIS OF TWEEDDALE seconded the resolution, and it was carried unanimously, after the Chairman had replied to a few questions and observations.

Resolutions were afterwards passed, re-electing the retiring Directors—Lord Sackville A. Cecil and Sir A. J. Leppoc Cappel—and the auditors, Mr. Henry A. Dever and Messrs. Welton, Jones and Co.

A vote of thanks to the Chairman and Directors closed the meeting.

[We shall publish a full report of this meeting in our next issue].

German Union Te'egraph and Trust Company (Limited).

An extraordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Tuesday, January 22nd, 1889, "for the purpose of considering and, if thought fit, passing special resolutions requiring the Company to be wound up voluntarily, and appointing a liquidator or liquidators for the purpose of winding up the affairs of the Company and distributing the property and fixing the remuneration of the liquidators." Sir James Anderson presided.

The SECRETARY (Mr. Wm. Payton) having read the notice calling the meeting,

The CHAIRMAN said that last March he told the shareholders everything it was then possible to tell them about the prospects of the winding up, and now they had come to the time for doing it. He was now able to tell them that the liquidators of the Berlin Company had declared a first payment of their Ordinary and Preference shares of 300 marks, or about £15 per share, which was their original par value. This sum would enable the liquidators of this Company to return to the shareholders about £7.7s.6d. per £10 share. A special extraordinary meeting would have to be held to confirm the resolutions now before them, when the liquidators would

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immediately distribute *pro rata* the amount received on account of their return of capital. It was expected that they would be in a position to make the first payment in the first week of February, and the final payment by the liquidators of the Berlin Company would be made at the end of April. They hoped to complete the winding up of the English Company and pay the balance early in May. So far as they knew at present, they trusted to be able to make a total return to the shareholders of very nearly par. There had, however, been an accident to the cable, which had since been repaired; and until the cost of this had been ascertained he could not say finally what the result would be. In conclusion, he moved a resolution for the voluntary winding up of the Company.

Mr. H. G. ERICHSEN seconded the motion, which was unanimously adopted.

A resolution was next proposed by Mr. ERICHSEN appointing Sir James Anderson and Mr. William Payton liquidators for the purpose of winding up the Company and distributing the property, and fixing their remuneration at £200, in addition to the expenses incurred.

The motion having been seconded,

The CHAIRMAN, in answer to questions, said he thought the shareholders would be repaid nearly par, but he could not state definitely within a shilling or two what the return would be. The winding up was a matter of force. They had not worked the cable since January, and it was now entirely in the hands of the German Government.

Mr. WILSON said he thought that as that was the case the German Government ought themselves to have paid for the repairs which had been effected since January.

The CHAIRMAN said they might talk in vain, but they could not help it. The payments to the shareholders might be 1s. 6d. or 2s. less than par. The Preference shareholders were a little better off than the Ordinary shareholders.

The resolution was then adopted and the proceedings terminated.

The Manchester Edison-Swan Company.

CENTRAL STATION LIGHTING IN MANCHESTER.

An extraordinarg general meeting of the proprietors of the Manchester Edison-Swan Company, Limited, was held on Tuesday in Manchester for the consideration of the question of supplying the electric light from a central station. In a second circular issued to the shareholders the Directors reminded them that if the proposed scheme be carried out it will entail a further call for capital. Mr. V. K. Armitage presided.

The CHAIRMAN said the Directors had called the shareholders together in fulfilment of a promise made at the very first general meeting of the Company, that they should take no step that would involve the raising of further capital without calling the shareholders together, explaining what it was proposed to do, and obtaining their consent thereto. The Directors were now about to make a proposal that would involve the calling up of from 30s. to £2 a share. Hitherto the Company had confined their business to making separate installations. They had made no attempt at a central installation, because the cost of the old system of distributing the electric current through thick copper mains was practically prohibitive. Like every other electric company in existence, for the first few years they lost money steadily, but last year they declared a dividend of 5 per cent. During the six months of the present year they had made profits which would enable them to pay another five per cent. Quite of recent years the system of distributing electricity had materially improved, and now the current could be sent at high tension down thin and inexpensive mains, and could be commuted when it arrived at a house into low-tension mains for domestic purposes. Under these circumstances, the Directors felt it their bounden duty to arrange for the supply of electricity from a central station in Manchester. There were a number of rivals in the field, and if that Company did not take steps to establish a central station in Manchester some other firm would. The Directors, therefore, suggested that a canvass should be undertaken by the Company to see how many people desired to have the electric light in the district they proposed to serve. For obvious reasons he could not enter into the full details of the scheme, but they had been very carefully prepared by Mr. Williamson. They proposed to establish a central station within half a mile of the Royal Infirmary for a maximum of 10,000 lights. They reckoned the cost of laying the mains at £40,000 and the cost of maintenance at £8,000 a year. If they let the whole of these lights at an average charge of 25s. a light that would bring in about £12,500 per annum. If the scheme was agreed to circulars would be issued and canvassers would be sent round to get replies, and if they had a promise of customers for 5,000 lights they would be justified in making a start. They would then try to persuade the Corporation to contract with them for the supply of the light without compelling them to go to Parliament. They would offer the Corporation strong inducements. They were willing to undertake to erect and maintain the station, and to provide a continuous supply of light. As the Corporation sold gas the Directors were willing to give them a royalty on every light they replaced with electric light, or give them a share of the profits at the end of the year. They were willing that the Corporation should lay the mains, and make all connections that involved the taking up of the streets, or that the Corporation should lay their own mains and the Company pay for the use of them, as was the case with the tramway lines. The Company were also willing to limit their profits to 10 per cent., and at the termination of a certain period to give the Corporation the privilege of buying the undertaking for the benefit of the ratepayers. If the Corporation withheld their consent the Company would have to apply to the Board of Trade, but this meant delay and increased expense. He moved:—

"*That this extraordinary general meeting of the Manchester Edison-Swan Company (Limited) approves of the proposed scheme for the establishment of a central electric lighting station in Manchester, and authorises the Directors to raise the requisite capital by making a call or calls not exceeding in the aggregate £2 per share as and when they may be required.*

"*The meeting expresses its earnest hope that the Corporation of Manchester may be induced to give the necessary facilities to enable the Directors to carry the scheme into effect.*

"*That a copy of the foregoing resolution be sent to the Mayor of Manchester and to every member of the Corporation.*"

Mr. I. C. WATERHOUSE seconded the motion.

Mr. WILLIAMSON stated what was being done in Bradford, London, and other places in the way of providing electric light from central stations. He was certain there would be a good demand for the light in Manchester, and that they would have no difficulty in placing from 5,000 to 10,000 lights on terms that would be profitable to the Company.

Mr. CHARLES HOPKINSON said the speculation did not appear to be an attractive one. The risk was very large and the profit limited. He had nothing to say against the scheme as a scheme, and he believed the directors were quite competent to carry it out. It was, however, inexpedient to make themselves too cheap in dealing with the Manchester Corporation.

The resolution was put to the meeting, and carried.

NEW COMPANIES REGISTERED.

ELMORE'S PATENT COPPER DEPOSITING COMPANY (LIMITED)—Registered by Newman, Hays and Co., 31, Abchurch-lane, London, E.C. Capital £200,000, divided into 100,000 shares of £2 each. Object, to purchase, take over, and work the whole of the British patents of Francis Edward Elmore, and all improvements thereunder whensoever made, relating to the treatment and electrical deposition of copper

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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and other metal, for the manufacture of copper and other metal articles, and to carry on the business of manufacturers of and dealers in copper and other metals. The first subscribers to the company are :—Sir J. H. Morris, 88, Queen's-gate, London, S.W. ; E. J. Carron, Rydal, Surbiton Hill Park, S.W. ; A. Holland, 2, East India-avenue, London, E.C. ; J. P. Beadle, 6, Queen's Gate-gardens, London, S.W. ; J. MacFarlan, Invermay, Wimbledon, Surrey ; G. Smith, West Bank, Lewisham-hill, London, S.E. ; F. L. Rawson, 11, Queen Victoria-street, London, E.C. There shall not be less than three nor more than nine directors of the company, and the first shall be appointed by the subscribers to the Memorandum of Association. Each director shall hold at least 250 shares in the capital of the company. The board of directors, exclusive of the managing director or directors, shall be entitled to a remuneration of not more than £1,500 per annum, together with 10 per cent. of the net profit of the company, after a payment of 20 per cent. dividend per annum to the shareholders.

THE MAXIM-WESTON ELECTRIC COMPANY (LIMITED).—Registered by Gresham and Davies, 12, Old Jewry, London, E.C. Capital £75,000, divided into 500,000 shares of 3s. each. Objects : To acquire and undertake the property and liabilities of the Maxim-Weston Electric Company (Limited) (in liquidation). To light streets, thoroughfares, public places, public or private buildings, manufactories, mines, houses, ships, etc. The first directors shall be John Marks, 113, Great Russell-street, W.C. ; James Gunton Couchman, Southwood, Eltham-road, Lee ; George Herbert Hildyard, 34, Wickham-road, St. John's, S.E. ; John Nathan Klenck, 43, Bishopsgate-street, E.C. ; and Louis Swaby, 23, Churchfield-road, Ealing. Each director shall hold at least 250 shares in the capital of the company. The remuneration to the directors shall be the sum of £1,000 per annum, to be divided amongst them as they may determine.

MINER'S LAMP ELECTRIC LIGHTING COMPANY (LIMITED).—This company was registered on the 12th inst., with a capital of £3,000, divided into 600 shares of £5 each, to acquire a certain invention and letters patent for miners' safety and other lamps and wicks. To carry on the business of a Safety Lamp Manufacturing Company and Electric Light Company in all its branches. Registered without special Articles of Association. Registered office, 71, Albion-street, Leeds. The purchase consideration is £1,000, payable £850 in fully paid shares and the balance in cash.

NEWCASTLE AND DISTRICT ELECTRIC LIGHTING COMPANY (LIMITED).—This company was registered on the 14th inst., with a capital of £50,000, divided into 5,000 shares of £10 each, to supply electricity for lighting and other purposes, whether public or private, in the city of Newcastle-upon-Tyne, or elsewhere in the United Kingdom. The first subscribers are :—The Hon. C. A. Parsons, Elveston Hall, Ryton-on-Tyne ; Sir B. C. Browne, Westacres, Newcastle ; J. D. Milburn, West Jesmond House, Newcastle ; J. B. Simpson, Hedgefield House, Ryton-on-Tyne, coal-owner ; H. C. Harvey, St. John's Chambers, Newcastle-on-Tyne, solicitor ; Earl Crawford, 2, Cavendish-square, London, W. ; A. F. Wade, 108, Victoria-street, London, S.W. ; W. M. Angus, St. John's Works, Newcastle-on-Tyne ; C. W. Spencer, Newburn Steel Works, Newcastle-on-Tyne. Registered without special Articles of Association.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).—At a meeting of the directors of this company, held on Friday last, it was resolved to recommend to the proprietors at the next half-yearly general meeting of the company, to be held on the 1st February next, the declaration of the following dividends :—

1. A balance dividend of 15s. per cent. upon the ordinary consolidated stock for the year ended 31st December, 1888.

2. A balance dividend of 30s. per cent. upon the preferred stock for the year ended 31st December, 1888, both payable on the 2nd February next, less income-tax, to the stockholders registered on the books of the company on the 14th inst.

After paying the foregoing dividends there will be an estimated balance of £1,325. 13s. to be carried forward to the next account. The above dividends, together with those already paid, will amount to £1. 12s. 6d. per cent. on the ordinary consolidated stock, and £3. 5s. per cent. on the preferred stock for the year 1888. The register of transfers of the company will be closed from 18th January to the 1st February, both days inclusive.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 18th amounted to £5,077.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED)—At a meeting of the board of directors of this company held on Wednesday the audited accounts for the half year to December 31st last were submitted, and it was resolved, after providing for the dividend on the Preference shares and placing £4,000 to the reserve fund, to recommend a distribution on the Ordinary shares at the rate of 9 per cent. per annum, free of income-tax, leaving £1,308 to be carried forward to the current half year's account.

EASTERN TELEGRAPH COMPANY (LIMITED).—Coupons on the Five per Cent. Debentures of this company due February 1st, will be paid on and after that date at the banking house of Messrs. Glyn, Mills, Currie and Co., 67, Lombard-street, E.C.

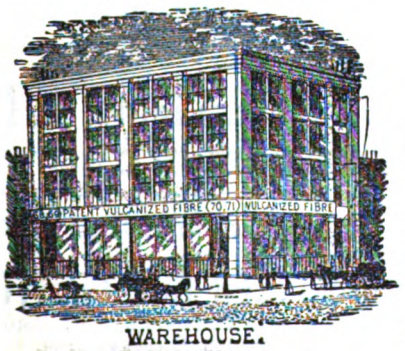
WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this company for the week ended January 18, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,195.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended December 31st, 1888, were £2,359, as compared with £2,805 in the corresponding period of 1887 ; and for the half-month ended 15th January, 1889, were £2,381, as compared with £2,676 in the corresponding period of 1888. The September traffic, estimated at £4,513, realised £4,540.

BELL'S ASBESTOS COMPANY (LIMITED).—The report of the directors of this company for the year ended December 31, 1888, states that the net profit from the ordinary trading of the company, after making all needful deductions, including depreciation of machinery and bad debts, was £23,429, and the net profit from the company's asbestos estates in Canada was £10,992, making a total of £34,421, from which the directors write off the whole of the preliminary expenses account, namely, £837 ; and under the terms of the Articles of Association they place £5,000 to reserve fund, thus leaving £28,585 for appropriation. They recommend the payment of a dividend of 15s. per share, free of income-tax, which, with the interim dividend paid in July last, makes a total distribution of 22½ per cent. for the year, and the payment of the bonus, £2,250, to the managing director and directors, in terms of the Articles of Association, carrying forward the balance of £3,835.

ELMORE'S PATENT COPPER DEPOSITING COMPANY.—Elmore's Patent Copper Depositing Company (Limited) has been formed to acquire and work the British patents for the discovery made by Messrs. F. Elmore and A. S. Elmore for manufacturing copper articles direct from rough copper bars, which does away with the processes of melting, rolling, forging, drawing, &c., and the present costly and laborious methods of manufacturing copper articles. It is claimed that by this process (see *The Electrician*, March 2nd, 1888, p. 436) articles are produced at a low cost, hitherto unknown, and that the invention is destined to take the same leading position in the copper industry which Bessemer's process has done in that of iron and steel. Distinguished professional men and leading technical experts are shown to have given high opinions of the invention, and to have recognised the process as entirely novel and practical, and calculated to largely supersede the present methods of working copper. Works in Sheffield have been secured by the company, and it is estimated that the machinery can be completed and the factory commence profitable work in about three months. The patentees have agreed to serve the company as managers for six years, at a fixed joint remuneration of £550 per annum, and a further sum of £100 between them for every 5 per cent. dividend paid to the shareholders. The company's profits will be obtained from licenses on royalties to the trade for the articles at present manufactured by them, and the earnings from the factory, which, it is estimated, will amount to over £100,000 per annum, equal to a profit from this source alone of over 70 per cent. per annum upon the capital. The amount to be paid by the company is £53,400 in cash, and £46,600 in fully paid shares, and the capital will be £200,000 in 100,000 shares of £2. It is stated that over 165,000 shares were applied for, against 43,600 to be allotted.

THE NON-CONDUCTOR OF ELECTRICITY.



WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

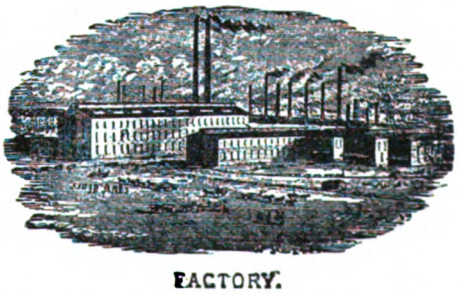
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb. ; HARD, 2/3 per lb.


FACTORY.

MOSSES & MITCHELL, 70 Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Jan. 23, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Jan. 23, 1889.	
£			**TELEGRAPHS.**		£ s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	50 51	2 13 5	Jan., Apr., July, Oct.	52¼	50
2,614,820	Stock	15/0	Do. Preferred	84 85	3 4 8	,, ,,	86⅜	85⅝
2,614,820	Stock	5/0	Do. Deferred	17 17½	...	February	18⅛	17
130,000	£10	3/0	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13 9/16	13 7/16
112,900	£100	5%	Do. 5 per Cent. Bonds	102 105	4 15 3	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9 0	Cuba Submarine	14½ 14⅝	5 15 3	February and August	14⅝	14½
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3¾ 4	3 10 0	March & September	...	..
6,000	5	5/0	Do. Preference 10%	8½ 9¼	5 5 3	April and October	...	..
60,710	20	3/6	Direct United States	10 10¼	3 18 1	Jan., Apr., July, Oct.	10⅜	9 15/16
330,000	10	2/6	Eastern	12⅝ 12¾	4 13 2	,, ,,	12⅝	12½
70,000	10	3/0	Do. 6 per Cent. Preference	14⅜ 15½	3 18 8	,, ,,	15¼	15
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	108	106½
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	110	109½
250,000	10	2/6	Eastern Extension	12⅝ 12⅞	5 1 0	Jan., Apr., July, Oct	13	12⅞
300,000	100	6%	Do. 6 per Cent. Debentures, 1891	104 106	5 13 2	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrin. Gov. Sub.) Debs. 1900	101 104	4 16 2	January and July	102¼	..
179,177	10	1/3	Globe Telegraph and Trust	7 7¼	5 4 11	Jan., Apr., July, Oct.	7¼	7 1/16
178,992	10	3/0	Do. 6 per Cent Preference	14½ 14⅝	4 1 4	,, ,,	14⅛	14¼
150,000	10	5/0	Great Northern	14½ 15	3 6 8	Jan., July, and April	15¼	14⅛
17,000	25	2/6	Indo-European	38 40	6 5 0	April and October	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
15,609	10	3/0	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	98	...
30,000	10	6/0	West Coast of America	8½ 9½	6 9 9	January and July	8⅛	...
150,000	100	8%	Do. Debentures 8%	117 121	6 12 3	June and December	117	...
88,321	10	nil.	West India and Panama	1⅝ 1⅞	...	...	1⅜	1 1/16
34,563	10	12/0*	Do. 1st Preference 6%	11¼ 11⅝	5 2 2	April and October	11⅝	11½
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	12	...
45,181	15	6 0	Western Brazilian	12⅜ 13	...	March & September	13	12
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅝ ¾	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	1/16 1/8	3 2 11	...	...	...
80,000	5	5/0	United	14 14½	5 3 5	June and December	14 1/16	14⅜
55,000	5	3/0	United River Plate	5⅝ 5⅞	...	January and July	5 3/16	5 1/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3⅜ 4⅛	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4⅛ 5⅛	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...	...	2⅜	...
312,000	¼	5% '86	Maxim-Weston	1/16 1/8	...	February	...	...
			MISCELLANEOUS.					
37,350	12	12 0	Telegraph Construction and Maintenance	41½ 42½	5 16 3	March and July	42½	41½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	18½ 19½	5 2 7	February & August	19	18¼

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 559.—Vol. XXII. FRIDAY, FEBRUARY 1, 1889. Price Fourpence.

NOTES.

At the end of the revised report of Sir William Thomson's Presidential Address will be found an appendix containing the formulæ from which the distribution of alternating currents in wires of different sizes may be calculated. Sir William also supplies a table which will greatly facilitate the calculation in the particular case where the current has 80 complete periods per second.

The extent of the deterioration to which copper is liable under the long-continued action of electric currents is a question upon which the evidence is somewhat contradictory, but it is at least certain that some samples have deteriorated to an alarming extent. We are therefore glad to learn from *La Lumière Electrique* that M. Firmin Larroque is carrying out a systematic investigation on this question, and that his experiments have already been four years in progress. M. Larroque has examined some wire taken from a lighthouse, which had been in use over twenty years; he found that its surface was pulverulent, it was easily broken by a hammer, and its texture was granular; in fact, it presented many of the properties of ordinary electrolytically-deposited copper. In another case in some wire taken from a secondary of a Ruhmkorff coil, and which had therefore been subjected to alternating currents, the degradation was even more marked. The coil could not be unwound without repeated fracture, and its resistance had increased by no less than 30 per cent. It is somewhat remarkable that in this case also its texture resembled that of electrolytic copper. M. Larroque's experiments are being conducted in the following manner:—He has taken thirty-six strips of copper each ten milliimetres in width and three millimetres in thickness (the length is not given). One half are bent into spirals and the other half into zig-zags, and some are annealed and some hard-drawn. They are suspended from a frame, and kept stretched by weights of 10 grammes attached to the lower ends. Each strip is traversed by a current varying from ·5 ampere to 2 amperes, which has been maintained constant since the commencement of the experiment. The current is alternating (at the rate of 75 reversals per second) in one set, and continuous in another. From time to time an exact measurement of the elongation of the spiral is obtained, and this is taken as a measurement of the loss of elasticity of the metal. For the first eight or nine months no effect was observed, but after that a slow elongation became manifest. The amount of elongation in the different specimens increased with the current, and was more marked with the alternating than with the continuous currents.

The fact which thus seems to be fairly well established that under the action of long-continued currents the molecular structure of copper tends to assume the condition of electrolytically deposited metal would seem to point to the use of conductors built up by the same process, in which case we might assume that there would be no further tendency to an alteration of texture. But it unfortunately happens (unless we are mistaken) that the electrolytically deposited wire at present in the market has its fibres laid transversely and not longitudinally, so that it would not possess any advantage in this particular. We shall be glad to be corrected if we are wrong in this assumption; and in any case it is scarcely possible as yet to say what amount of practical importance attaches to the question.

Prof. Brackett, of Princeton College, in an interesting address delivered before the New York Electric Club, spoke hopefully of the problem of obtaining light without heat. He is going to experiment with polarised light in order to see if it is possible to evoke electro-magnetic waves of high-periodicity in a conducting medium—so that he proposes to attack the problem in the first instance from the rear. In a passage which is perhaps intentionally obscure Prof. Brackett intimates his opinion that "we must get something that is not a conductor in the ordinary sense," and he sees "very hopeful indications" in the known properties of selenium.

In addition to Prof. Forbes's valuable Paper on "Electricity Meters," our readers will also find in the present issue a description of the Hookham meter, which seems likely to play an important part in central station work. It is one of the simplest and also one of the most ingenious meters which has yet come under our notice, and is additionally interesting as being one of the very few instances in which Foucault currents are made to do useful service. The meter is already at work not only at Leamington but also in Liverpool, where it is used by the Liverpool Electric Supply Company. We may add that this meter bears some resemblance to an instrument of the same class patented by Messrs. Siemens some years ago; but we have not heard that the latter has ever been brought into use.

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In the discussion on Prof. Forbes's Paper at the Society of Arts last week, the question of the most suitable candle-power for domestic lighting evoked considerable divergence of opinion. With Prof. Forbes's strong condemnation of the practice of running 16 candle-power lamps at 8 or 10 candles everyone will emphatically agree, and, indeed, we believe that the extent to which this is now being done in the West End is injuriously affecting the immediate prospects of electric lighting—at any rate in that neighbourhood. Anything better calculated to provoke disgust than the "red hair-pin" style of illumination (?) it is difficult to imagine. On the other hand, we may place reliance on the experience of Mr. Crompton and others, who find that for private houses lamps rated at 8 candle-power and burnt at 8 candle-power fulfil the public requirements to a very large extent. It is not the policy of the Electricity Supply Companies to run up the bills of the consumers, and for passages, halls, offices and rooms of medium size, there can be little doubt that 8 candle-power lamps are amply sufficient for all practical purposes. For larger rooms, where several lamps are required, it becomes a question of effecting the best distribution of light, and each case must be settled on its own merits. We would also endorse Mr. Preece's protest against the rating of dynamos or central stations in terms of lamps, unless the number of watts be stated. Mr. Preece proposes that a "lamp," unless otherwise specified, should be a lamp of 50 watts. This is a suggestion which will probably commend itself to most people.

The West Brompton Station of the House-to-House Electric Light Supply Company was opened with some *éclat* on Thursday week. So far as we have had an opportunity of judging it appears to be a very creditable piece of work, and one of which the company has every right to be proud. We are sorry not to be in a position to criticise the details, but the fact is that—doubtless by some oversight—the visit of the technical press was made concurrent with that of the general public, who were present in great force. We mention the circumstance less by way of complaint than as an explanation of the fact above mentioned. The account on another page is abstracted from a pamphlet with which the visitors were presented.

On another page will be found some details of the important contract which Messrs. Mather and Platt have entered into with the City and Southwark Subway Company, for the equipment and working of the line from Stockwell to London Bridge. We are extremely pleased that an opportunity has thus arisen which will enable Dr. Ed. Hopkinson to show what electric traction, under favourable circumstances and in competent hands, is capable of accomplishing. As to the complete success of the undertaking we have no misgiving whatever, and there is also little doubt that it will impart a most valuable and much needed impetus to electric railway work in this country.

If the time should ever arrive when the apparition of a horse in the business quarters of our great towns will have become a comparatively unfamiliar spectacle, then we should be sincerely grieved if the finger of scorn could be pointed at the pages of *The Electrician* in which the possibility of such a result had been denied. We desire, therefore, to state that we have not committed, and do not now commit ourselves, to any such denial. But the question which has of late been forced upon our attention is whether in the present state of the art of electric traction by batteries it is practicable to employ this means for the propulsion of vehicles upon ordinary roads, and to do so upon a strictly commercial basis. This problem has for some time engaged the attention of a well-known electrical engineer, Mr. Radcliffe Ward; and as the result of a series of experiments extending over several months, during which his "electric omnibus" has traversed some 200 miles over the London streets, Mr. Ward is of opinion that he is entitled to answer the question in the affirmative. Now it will scarcely be necessary on our part to state that we should like nothing better than to be convinced of the soundness of a scheme which promises greatly to extend the domain of the commercial application of electricity; and in the event of success we should desire to be amongst the first to congratulate Mr. Ward upon a very noteworthy achievement. But we must reluctantly confess that, after having enjoyed opportunities of becoming acquainted with the details of the project, and having taken time to consider the question to the best of our ability and in all its bearings, we have not succeeded in convincing ourselves that it ought to receive such support as for many reasons we should have wished to be able to afford.

It seems scarcely necessary to recapitulate in detail every difficulty or objection which arises in the contemplation of a scheme of this character. From the commercial point of view we have to inquire how it comes to pass that a mode of traction which has not yet proved an indisputable success when applied to vehicles running on rails can be expected to give satisfactory results under the far more exigent conditions of ordinary street traffic. From the technical point of view we want to be assured that the weight, durability and rate of discharge of the batteries, the arrangements for recharging, the method of driving and steering the vehicle, and other matters of detail which readily suggest themselves, have been brought to the necessary degree of perfection. (Here we must, in justice to Mr. Ward, remark that in some of these points his arrangements seem to be of a specially promising character, and, at least, display considerable ingenuity.) But there is yet another point of view on which we should be doing wrong to maintain silence, and where the only conclusion at which we are able to arrive is one of an adverse character. Under existing circumstances would the admission of electrically-propelled vehicles upon our ordinary streets be consistent with due regard to the public safety? Remembering that the driver will have to handle steering gear as well as the starting, stopping, and slowing levers, remembering also that the addition of batteries and motors will probably increase the dead weight to at least three times that of existing vehicles of the same description, we are unable to see our way to accept the responsibility which would be entailed by advocating their introduction. On the other hand, it is only fair to give Mr. Ward the credit of having

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conducted his experiments so far without any accident—save one of a humorous description for which he was not personally responsible. And again, we do not say that the objection applies so seriously to slow-moving vehicles, such as trolleys and dust-carts (to both of which Mr. WARD hopes to apply the method); only in this case the technical difficulties, owing to the strain on the batteries, motors, and gearing, are very great. Finally, there is the legal question. Mr. WARD is advised that there is no existing law interfering with the project, and that the red-flag clause does not apply. He is, however, very properly desirous that the subject should be placed under the control of the Board of Trade. We cannot avoid a feeling of regret that Mr. WARD should not have devoted his very considerable talent and energy to a cause, such as that of tramcar traction, in which he would not have been encumbered with the serious difficulties which we have felt it our duty to name.

Restoration of the Falmouth and Bilbao Cable.—The cable of the Direct Spanish Telegraph Company between Falmouth and Bilbao is now repaired.

"Modern Views of Electricity."—The papers on "Modern Views of Electricity," by Prof. Oliver Lodge, which have been appearing in *Nature*, will soon be published as a volume of the "Nature Series."

Patent Litigation in the States.—The action which M. Camille A. Faure has brought against the Cowles Electric Smelting Company for infringing his electric smelting patents is now proceeding.

Liverpool Tramways.—The Liverpool Tramways Company have decided, as soon as possible, to abandon horse-power in favour of some form of electrical or mechanical traction. They are open to suggestions on this point.

St. Martin's-in-the-Fields Vestry.—At a meeting of this Vestry on Thursday last week consent was given to an application for a license authorising the House-to-House Electric Supply Company to supply electricity within the parish.

St. Mary Abbotts, Kensington.—The local authorities of the parish of St. Mary Abbotts, Kensington, have decided to apportion to the House-to-House Electric Supply Company a district which is bounded by Cromwell-road, Fulham-road, and Onslow-square.

Fleming's Practical and Useful Diary for 1889.—This little publication, issued by Messrs. Thos. Fleming, Son and Co., of Halifax, manufacturers of machine-bands, fully justifies its title of practical and useful, containing, as it does, an immense amount of valuable information about belts of all sorts.

London Central Subway Railway.—A meeting will be held at the Holborn Town Hall this day (Friday) at 8 p.m., when the system proposed to be adopted in connection with the above railway will be explained, and a model exhibited. Those of our readers who are interested in the scheme will doubtless be welcomed.

Ipswich.—At the fortnightly meeting of the Paving and Lighting committee, held on Friday last, the clerk laid before the committee a copy of the license for which Messrs. Laurence, Paris and Scott proposed to apply to the Board of Trade. He suggested that it should be referred to someone conversant with the matter.

Hove.—At a special meeting of the Hove Commissioners on Saturday last, it was decided to oppose the Provisional Order sought by the Brighton and Hove Electric Light Company (Limited). One of the reasons assigned for this decision was that "the science of electric lighting was not sufficiently advanced to warrant the grant to any company of statutory power to break up the public streets."

Islington Vestry.—The Special Committee appointed to consider the applications of the London Electric Supply Corporation and the Metropolitan Supply Company, asking for the Vestry's assent to their application for Provisional Orders, recommended that the clerk be directed to lodge objections to such Provisional Orders with the Board of Trade, in order to secure a *locus standi*.—The adoption of the report was carried.

The "Industries" Motor Competition.—A correspondent writes to us: "Can you or any of your readers give information about the prize competition for the design of a 10 horse-power electric motor which was instituted by your contemporary *Industries* at the end of 1886? Have the judges come to any definite decision? And why are the designs of the unsuccessful competitors refused to be returned at this date, after more than two years' detention?"

St. Saviour's (Southwark) Board of Works.—At a meeting of the St. Saviour's (Southwark) Board of Works on the 23rd inst. the General Purposes Committee reported that they had considered the several notices and applications under the Electric Lighting Acts, and were of opinion that no opposition should be offered to the schemes for lighting the district by means of electricity, but that representations should be made to the Board of Trade that all wires in connection therewith should be laid underground.—The report was adopted.

Liverpool Electric Supply Company.—On Tuesday last a deputation, representing the Liverpool Electric Supply Company, waited upon the Watch Committee of the City Council and endeavoured to procure their assent to the Provisional Order which the company intend to seek during the forthcoming session of Parliament. In spite of an unusually protracted consultation it was found impossible to come to terms, and the practical result, therefore, is that the Watch Committee will refuse their assent to the company's application.

Metropolitan Board of Works.—At a meeting of the Board last week, Mr. Hughes, M.P., brought up the report of the Parliamentary Committee, which set forth that they had considered the electric lighting provisional orders referred to them by the Board and recommended that the solicitor should be instructed to communicate with the Board of Trade, requesting further time to submit any necessary observations and such revisions to detail as might be desirable to meet the objections of the Board. The recommendation was agreed to.

The Manchester Telephone Staff.—On Friday, the 25th inst., the Manchester staff of the Lancashire and Cheshire Telephonic Exchange Company (Limited), held their fifth annual *soirée* at the Manchester Athenæum. There was a large attendance of officials and friends, and a most enjoyable evening was passed. As in each previous year, Mr. Joseph Poole (chief electrician to the company) made an able and popular "M.C.," and his efforts were well supported by the stewards, Messrs. R. F. Beer, T. J. Clark, W. G. Heys, A. Hodgkinson, and E. Whitworth.

Newcastle.—A meeting of the sub-committee of the Newcastle Town Improvement Committee was held on Wednesday last week to consider the applications made, one by Messrs. Leadbitter and Harvey, and the other by Messrs. Watson and Dendy, on behalf of two separate companies for the concurrence of the committee in their applying to the Board of Trade for powers to supply the electric light in Newcastle. Representatives from the respective promoters were present, who explained what it was intended to do. The feeling of the committee was favourable to the consent of the Corporation being given, as long as there was no monopoly created, and provided the wires were placed underground. The matter will be further considered at a special meeting.

A Statue to Ohm.—A meeting was held yesterday afternoon in the Royal Society's meeting room to appoint a committee, with a view of obtaining subscriptions in aid of a proposed memorial to Ohm. The 16th of next March will be the hundredth anniversary of the birth of George Simon Ohm, and in view of the near approach of the centenary of the birth of a man who has done so much for electricity a committee has been formed in Germany to promote the erection of a statue of Ohm in Munich, the capital of his native state, Bavaria, and the city in which the latter part of his life was spent as professor of physics in the university. The co-operation of those who in other countries take an interest in this design of honouring

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the memory of a benefactor of his race has been invited by the German Committee.

Gas Mains as Electrical Conduits.—The problem of conveying telephone and electric lighting wires underground in large cities has received a partial solution in New York, where for the last few years a telephone conductor has been run inside a gas main, between the gasworks of the Consolidated Gas Company, at 99th and 111th-streets. The conductor enters the gaspipe by a stuffing-box, made gas-tight by plaster of Paris. The wire is carried by glass insulators fixed in the roof of the pipe. The length of the circuit is over half a mile, and it has been in continual use. Owing to the success of this experiment a series of new mains have recently been supplied with telephone cables serving for the use of the gas company. The experiment tends to show that the disused mains of a gas company might profitably be employed for running the wires of an electric lighting company underground.

Lambeth Vestry.—At a meeting of the Lambeth Vestry on Thursday evening last week a letter was read from Messrs. Deacon, Gibson, and Metcalf, enclosing copy of a draft Provisional Order deposited with the Board of Trade by the London Electric Supply Corporation, and asking the Vestry's assent to the same. Messrs. Bircham and Co. wrote on behalf of the Metropolitan Electric Supply Company, asking for similar assent. A further letter was read from the Wandsworth District Board of Works, inviting delegates to a conference on the question of electric lighting in South London, to be held in the hope of securing, by combined action, such amendments in Provisional Orders as were calculated to fully protect the interests of the public generally and the road authorities. These communications were referred to the Electric Lighting Committee for consideration and report.

Lithanode.—Mr. Oswald Swete, of the Mining and General Electric Lamp Company, writes as follows:—"I have been asked by our consulting electrician, Mr. D. G. FitzGerald, to forward you some samples of 'lithanode,' which I now do. Hitherto, by the policy of other companies who previously owned and worked the patents, lithanode has been most jealously guarded from the public gaze, and no samples have been issued for experimental purposes to the public. My directors, however, have decided to issue such samples to anyone who does not mind the trouble of applying for the same, enclosing a stamped addressed label. You will see by the small plate one method of connection, and I think the best, Bunsen battery clamps with platinum foil, however, may be used, also carbon contacts. One ounce of this material will give one ampere-hour discharge. The plates can be cut easily by the aid of a fret saw. With zinc as a cathode, the E.M.F. is 2·375 per cell; in an electrolyte such as dilute sulphuric acid sp. gr. 1·170."

St. George-the-Martyr Vestry.—At a meeting of this Vestry on the 22nd inst. Mr. Sinden moved the adoption of a report from the Roads Committee, recommending that this Vestry dissent from the granting of a Provisional Order by the Board of Trade to the London Electric Supply Corporation (Limited) for the supply of electricity in this parish, under the Electric Lighting Acts; that this Vestry assent to the granting of a license by the Board of Trade to the House-to-House Electric Lighting Company (Limited), authorising that company to supply electricity within this parish. Mr. Sinden said the Committee objected to the first application, because a Provisional Order would give the company privileges in the parish for forty-two years. The second company asked for a license which would only extend over seven years. A long discussion ensued. The first recommendation was adopted, but the consideration of the second recommendation was deferred until the next meeting of the Vestry, in order that the representatives of the House-to-House Company might be in attendance.

Dublin.—A correspondent writes from Dublin as follows:—"In Dublin considerable interest is at present being aroused in connection with electric lighting. At a meeting of the Municipal Council last Monday it was all but unanimously resolved—there being only one dissentient—to apply to the Board of Trade for a license for *private* lighting. It will be remembered the Council have already acquired a license for *public* lighting, and seeing that greater advantages would necessarily attach to the privilege of dealing with the question in a general way, the local authorities are acting wisely in thus amending their position. Meantime, the Dublin Alliance Gas Company have put down a new installation during the year, and are at present lighting several of the large business houses throughout the city with both arcs and incandescents and are offering inducements to new customers. There are also several isolated installations working satisfactorily in Dublin, notably those at Messrs. Guinness's Brewery, Messrs. Findlater's, Chapelizod Distillery Company, &c., &c., and perhaps the most complete and successful installation in Dublin is that at the offices of the Irish *Times*, which was put down five years ago, and has been working continuously since under the superintendence of Messrs. J. K. Fahie and Son, electrical engineers of Dublin, giving the greatest possible satisfaction to the *employés*, especially the compositors, whose work is carried on during the greatest part of the night."

Electric Traction in Coal Mines.—In a Paper read by Mr. A. W. Sheafer before the Engineers' Club of Philadelphia we read "that the Lykens Valley Coal Company, at its mines in Dauphin County, Pa., has introduced the electric locomotive with, it seems, considerable success. The road here is 6,300ft. long, supplied with a third rail carried along the side of the gangway. The average load is 20 cars per trip, or 850 tons per day, equivalent to 1,040 mile-tons per day. The Union Electric Company, which furnished this plant, gives the daily expenses of running the locomotive as $5.71, or a cost per mile-ton of 0.67 cent. This, they claim, can be reduced by the use of better graded roads and heavier mine waggons to 0.40 cent. per mile-ton. The writer, in a former Paper, gave the relative costs of mule and steam locomotive haulage at Kalmia Colliery, and now introduces them here for comparison with electricity as follows:—

	Mule.	Steam.	Electricity.
Cost per ton-mile.....	1·82 cent.	0·60 cent.	0·40 to 0·67 cent.

It should be borne in mind that the cost as regards mule and steam power are based upon the prices of 1882, while the estimate for electricity is for 1887; consequently, the comparison is not entirely a just one; but it is made to show that we may expect under favourable circumstances electric haulage to at least do the work required as cheaply as steam power, and with less attendant danger to the mine."

Sir John Pender and the Glasgow Telegraph Staff.—The following is the reply from Sir John Pender to the address from the telegraph staff which was forwarded to him on the 21st inst.:—

"18, Arlington-street, London, S.W.
"22nd January, 1889.

"Dear Sir: I am in receipt of your favour of the 21st inst., enclosing an address from the Glasgow postal telegraph staff. I value it very much, because it is an evidence on the part of those who can best understand the importance of the work of the great value of the submarine system, and I am very pleased to learn from those who have signed the address that they approve of the manner in which the submarine system is conducted.

"It has been my ambition, and the ambition of those associated with me, to do full justice to the telegraphing public, and also to the *employés*, in whose hands the proper execution of the great work lies.

"Submarine telegraphy has been one of the remarkable combinations of science and commercial enterprise of the age. I hope it will ever remain non-political, and that in its development it will continue to bind the nations of the world more closely together, particularly our vast empire, of which we all ought to be so proud, and which it ought to be our ambition to maintain.

"Thank all the subscribers for me, and assure them of my sympathy and interest.—Yours faithfully,

(Signed) "JOHN PENDER

"D. Mackie, Esq., Accounts Branch,
Post Office, Glasgow."

The Proposed Electric Traction on the Metropolitan Railway.—In the report of the Metropolitan Railway Company which has just appeared the following reference is made to the proposed electric traction experiments:—"The directors regret that the Electric Traction Company have not been able to complete their arrangements for the experimental working, by an electric-power locomotive, on a section of your railway. The

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following letter from the chairman of the Traction Company has been received :—

"The Electric Traction Company (Limited),
"New Broad-street House, London, E.C., 31st Dec., 1888.
"The Board of Directors, Metropolitan Railway.

"Gentlemen : In reply to your inquiry respecting the progress of the electric locomotive for your company, I have to say that the difficulties which were spoken of in your last report, which principally concerned the working of the vacuum brake without the use of steam, though intractable for a considerable time, have now been overcome. The whole matter is in active progress, and has made considerable advance since the last report.

"The Electric Traction Company wish it to be explained that an erroneous belief appears to be entertained that they propose to suggest traction by means of accumulators for ultimate use on the Metropolitan line. This is not the case. The use of accumulators is for a temporary service only, and is rendered necessary by circumstances connected with the traffic, which will disappear when electric traction is adopted on the underground railway.

"I am, Gentlemen, yours faithfully,
"(Signed) BURY,
"Chairman, Electric Traction Company."

The City.—As we mentioned last week, the report of the Streets Committee of the City Commissioners of Sewers was ordered to be printed and circulated. The draft conditions under which tenders are to be invited for supplying electric lights for the City have now been issued. The main thoroughfares and public streets of the entire area of the City are to be lighted by electricity, and, for the sake of convenience, are to be divided into three districts (west, central, and east), the contractors being at liberty to tender for either one or two of the districts or for the entire City. The existing system of gas lighting will not be interfered with, but the contractor will be allowed in certain cases, with the consent of the engineer, to use any of the existing gas columns or brackets. The electric lamps must be fixed on such standards as the commissioners may approve. It is to be obligatory on the companies to lay all wires and conductors beneath the public way. The whole of the main thoroughfares are to be primarily lighted ; the companies to state the period at which the lighting of the thoroughfares will commence, and when it will be extended to the remaining streets. One condition is that when the profits have reached a cumulative dividend of 10 per cent. the surplus shall be divided equally between the contracting company and the consumers. The Commission will consider a report to this effect and the conditions of the proposed contract at their next meeting, and, if adopted, tenders will be advertised for on the basis thus laid down.

The New Electric Light Works of the Elwell-Parker Company.—The directors of the Elwell-Parker Electric Light Company (Limited), Wolverhampton, propose to erect entirely new works in order to meet their growing trade, and lately they have acquired twelve acres of land adjacent to Bushbury Junction, on the main line of the London and North-Western Railway Company. It is only some seven years ago that Mr. Elwell and Mr. Parker started the works in Commercial-road with the object of making a speciality of electric lighting apparatus. Two years afterwards Mr. Charles Moseley, of Manchester, and a few friends joined the firm, and the present company of Elwell-Parker (Limited) was formed on the 3rd September, 1884. At that time not more than thirty hands were employed on the works. At the present time the firm have an order on hand to supply a central station for giving 20,000 lights in Melbourne, and have just completed a contract for dynamos for the central station for the House-to-House Company in South Kensington. A year ago they sent out one of their electric cars to Sydney, where it was thoroughly tested, and it has now been adopted for use on the Ballarat tram lines. Since then a complete tramcar plant has been sent out to Melbourne. In the manufacture of accumulators the firm have been exceedingly busy for years, and they are now using from ten to twelve tons of lead a week in the output of these articles. As the business expanded the number of hands in the employ of the firm grew, until to-day there are 500 at work. About eighteen months ago Mr. Elwell left the firm, and a year ago, on the death of Mr. Charles Moseley, his brother, Mr. Joseph Moseley, assumed the position of chairman of the company.

St. George's (Hanover-square) Vestry.—At a meeting of this Vestry on the 24th inst., the Electric Lighting Committee submitted a long report, which showed that the following companies were applying for Provisional Orders to supply the parish with the electric light :—The London Electric Supply Corporation (Limited), Metropolitan Electric Supply Company (Limited), Westminster Electric Supply Company (Limited), and the Chelsea Electric Supply Company (Limited). The report recommended that the application of the latter company should be refused, and, if necessary, opposed before the Board of Trade; that the matter be referred back to the committee for negotiation with the three other companies, with a view to altering their drafts in certain particulars ; and that the Vestry authorise the committee to instruct Messrs. Caprons and Co., solicitors, to oppose all or any of the four schemes, as might appear expedient. The suggested alterations included binding the companies to complete any works within eighteen months from the date of the order, instead of two years ; that, provided a company fail to perform its obligations to light any place, a money penalty should be inflicted rather than a revocation of its order as to that particular place ; that the quality of the lighting should be subject to the inspection and superintendence of the County Council ; and that deposits of £500 should be made to answer damages by works which might be begun and never continued. Such a deposit the committee would not ask for in the case of the London Electric Supply Corporation, because it had valuable work in that parish and elsewhere, and was thoroughly responsible. The Metropolitan and Westminster Companies were not in any such position, and it was thought prudent to require a deposit from them. The adoption of the report and recommendations was agreed to unanimously.

The Thomson-Houston Electric Company.—The handsome and attractive volume recently issued by the Thomson-Houston Electric Company, of Boston, U.S.A., is another addition to that style of catalogue which the Americans have made so peculiarly their own. The book before us contains some 90 pages, numerous and well-executed engravings, besides clear and terse descriptions of the various Thomson-Houston apparatus. Anything approaching technical detail is carefully avoided ; to such an extent, indeed, has this feature been carried that in the case of the Thomson-Houston transformer we are only permitted to see back and front views of the external casing. However, the catalogue is just what the public requires ; the fine illustrations and plain English descriptions preparing the ground for price-lists and technical details. It seems to us that many of our large English firms might do well to imitate this artistic method of imbuing the public with a proper sense of the value of the electric light. The volume appropriately commences with three cuts depicting the Thomson-Houston factory as it was in the years 1882, 1886 and 1888 respectively, and the growth of the factory has apparently been commensurate with the growth of the system. In January, 1884, there were 2,478 arc lamps running on the Thomson-Houston system. In January, 1888, this number had risen to 36,936 arc lamps, and 74,425 incandescent lamps had to be added. By January, 1889, these totals were respectively 52,000 and 97,067, an increase of over 13 per cent. in each case. We are glad to note, moreover, that nearly 60 gas companies are working stations on the Thomson-Houston system. On page 25 we notice a remarkably good illustration of the Thomson-Houston "Controller Magnet and Regulator." Several pages of engravings of various pattern Thomson-Rice arc lamps come next, and amongst these a form of lamp for use in "low-studded" mills, which possesses the usual good features of the ordinary lamp with the additional advantage of being only 27 inches long. We come next to small search lamps intended for use on board yachts and ships of the mercantile marine, which are made to give from 2,000 to 6,000 candles. On page 49 a new type of Thomson-Houston dynamo for incandescent lighting, with single horse-shoe vertical magnets like the Thomson-Houston meter, is Illustrated. The rest of the book is taken up with descriptions of the Thomson-Houston compensator system, alternating current dynamo, and automatic cut-outs for incandescent lamps run on the multiple series system, the concluding pages being devoted to engravings of various model stations.

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ELECTRICAL TRACTION ON THE CITY OF LONDON AND SOUTHWARK SUBWAY.

The method of construction and the system of working of the City of London and Southwark Subway mark a new departure in the methods of communication in our large towns, and will probably afford a complete solution of the problem of underground railways. The subway consists of two tunnels, each 10 feet 6 inches in diameter, formed of segmented cast-iron plates. It extends from the Stockwell terminus at Clapham-road, by the Oval and "Elephant and Castle" at Newington, and then under the Thames to the City terminus at King William-street, the total length of each tunnel exceeding three miles. There will be stations at the Monument, King William-street, Great Dover-street, the "Elephant and Castle," the Oval, and at Stockwell.

As the method of construction, which is entirely novel, has been already frequently described, we need not allude to it more particularly now, but it is only quite recently that the system of traction to be adopted has been finally decided. The original Act of Parliament specified that the traffic should be worked by means of carriages propelled upon the system of the cable tramway, but about a year ago the success of the Bessbrook and Newry Electrical Tramway and other similar undertakings led the directors to consider the adoption of electrical working, and they entered into communication with Messrs. Mather and Platt, of Manchester, on whose behalf Dr. Edward Hopkinson, the managing partner of their electrical department prepared a detailed and elaborate scheme. The matter was under discussion for some months, and finally tenders were invited from the most eminent electrical engineering firms. The result has been that the scheme of Messrs. Mather and Platt has been adopted in its entirety, as affording a perfectly satisfactory and feasible solution of the problem, and a contract has been placed with them for the carrying out of the entire work. The generating plant will be placed at the Stockwell terminus, where boiler and engine plant of over 1,000 horse-power will be erected, and three large Edison-Hopkinson generating dynamos. The current will be conveyed by a lead-covered cable throughout the whole length of the line, and Dr. John Hopkinson's system of overhead conductors will be adopted for conveying the current to the locomotives. This system has proved a great success on a small scale at Bessbrook, and is particularly well adapted for such an undertaking as the subway. There will be 14 electrical locomotives, each capable of developing 100 horse-power, which is sufficient for moving a train containing 100 passengers at 25 miles per hour, and for providing the great power required for starting rapidly. The trains will run at intervals of three minutes, and each consists of three cars. In addition to the plant required for electrical traction Messrs. Mather and Platt's contract includes the lighting of the trains and of the stations, and of the hydraulic lifts and approaches.

The experience gained by Dr. Edward Hopkinson on the Bessbrook and Newry line, which, though on a much smaller scale, is still of the same character, and which has proved a most unqualified success, has solved many difficulties in connection with electrical traction, and will be of great value in the present undertaking.

Mr. James Henry Greathead is the engineer of the Subway, to whose designs the entire works have been constructed; Sir John Fowler and Mr. Benjamin Baker are the Consulting Engineers, and Mr. Spagnoletti the Consulting Electrician.

We append the following extract from the report of the Subway Company which is to be submitted to a meeting of the shareholders on February 12th:—

In accordance with the resolutions passed by the shareholders at the last half-yearly meeting, the Directors have devoted a large amount of attention to the question of the best method of electrical haulage, suitable for efficiently working the traffic upon this line, and they invited proposals from several of the chief electrical manufacturers. After a very exhaustive examination into the details of the several different proposals, your Directors, acting under the advice of the Company's engineers, and aided by the valuable assistance of Mr. C. E. Spagnoletti, an experienced electrical engineer, have entered into a contract for the installation of the necessary machinery and plant with the well-known engineers, Messrs. Mather and Platt, of Manchester, the electrical department of whose business is under the immediate direction of Dr. Edward Hopkinson, who has had exceptional experience in electric traction.

It is with much pleasure that your Directors are enabled to report the satisfactory conclusion of their investigations upon this most important subject. The contractors have undertaken to provide the power necessary to run a three minutes' service from each station at a greater average speed than that now attained on the Inner Circle of the Metropolitan Railways, and they also guarantee for a period of two years the cost per train mile at a considerably lower rate than if steam locomotives were used. Your Directors have the fullest confidence that these provisions will be duly carried out, and will result in the establishment of a system of underground conveyance for the metropolis of an exceptionally convenient character, and worked at such a cost as will give a satisfactory return to the shareholders. The electrical power provided includes also the lighting of the trains and stations.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

SIR WILLIAM THOMSON'S PRESIDENTIAL ADDRESS.*

"Electricity, Ether and Ponderable Matter."

(Concluded from page 334.)

But now there is another line of thought in connection with this subject, and that is the elastic solid idea. Will you allow me to read a very short statement which was published in the *Cambridge and Dublin Mathematical Journal* for the year 1847? It is dated Glasgow University, November 28th, 1846. It was written after I had been twenty-eight days at work in my professorship, and it is as follows:—"Mr. Faraday in "the 11th series of his 'Experimental Researches on Electri-"city' has set forth a theory of electrostatical induction "which suggests the idea that there may be a problem in the "theory of elastic solids corresponding to every problem con-"nected with the distribution of electricity on conductors or "with the forces of attraction and repulsion exercised by "electrified bodies. The clue to a similar representation of "magnetic and galvanic forces is afforded by Mr. Faraday's "recent discovery of the affection with reference to polarised "light, of transparent solids subjected to magnetic or electro-"magnetic forces. I have thus been led to find three distinct "particular solutions of the equations of equilibrium of an "elastic solid, of which one expresses a state of distortion, such "that the absolute displacement of a particle in any part of the "solid represents the resultant attraction at this point pro-"duced by an electrified body. Another gives a state of the "solid in which each element has a certain resultant angular "displacement, representing in magnitude and direction the "force at this point produced by a magnetic body; and the "third represents in a similar manner the forces produced by "any portion of a galvanic wire; the directions of the force in "the latter cases being given by the axes of the resultant "rotations impressed upon the elements of the solid." Then come the mathematics, in three pages, and then comes the last sentence. "I should exceed my present limits were I to enter into "a special examination of the states of a solid body represent-"ing various problems in electricity, magnetism, and galvanism, "which must, therefore, be reserved for a future Paper." As to this last sentence, I can say now, what I said forty-two years ago, "*must be reserved for a future Paper!*" (applause). I may add that I have been considering the subject for forty-two years—night and day for forty-two years. I do not mean all of every day, and all of every night—I do not mean some of each day and some of each night. But the subject has been on my mind all these years. I have been trying, many days and many nights, to find an explanation, but have not found it.

Let there be an elastic solid body of exceedingly small density, and let there be a tubular portion of it porous, but with the same aggregate rigidity as that of the continuous elastic matter around it. Let the pores be filled with a dense viscous fluid, and let this fluid be forced, by aid of a piston or otherwise, to move through the tube. The pull of the fluid upon the porous solid will produce static rotational displacement exactly pro-

* Revised by Sir William Thomson.

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portional to the continued rotatory motion which we had in in the case of the viscous fluid. Some of the most interesting practical problems of electro-magnetic induction can be dynamically realised, as it were, in model, by following out this idea; in fact, if we had nothing but electricity and ether, the thing would be done. If it were not for the gross ponderable matter that we are forced to consider, I should be perfectly satisfied with the problem of electro-magnetic induction, by taking the electricity as a viscous fluid, and ether an elastic solid, porous in some places, and continuous or non-porous elsewhere (applause.)

Now, if you will pardon me, though it is very late for introducing another topic on which to speak, I shall confine myself to one, and that is magnetism (applause.) I must return to the rotational case. Imagine this (Fig. 2 or Fig. 3) to be the section of an ordinary helix or solenoid with a solid copper core. Imagine a continuous electric current (Fig. 2) or an alternating electric current of electricity sent (Fig. 3) through it. Whatever the current of electricity may be, I believe *this* is a reality, *it does pull the ether round* within the solenoid. I do not think this is a dream of electro-magnetic theory—I believe it to be a reality. Whatever ether is we move through it—the earth moves through it. Astronomers and opticians do not cry out and make their lives miserable because of the aberration of light. Fresnel and Prof. Stokes have done all that man, up to the 9th of January, 1889, has been able to do to explain the dynamics of the aberration of light. It may be not beyond man's range to complete the solution—how the earth can tear through this elastic solid ether and yet the waves of light be propagated through it as they are. The aberration of light is still an absolute mystery.

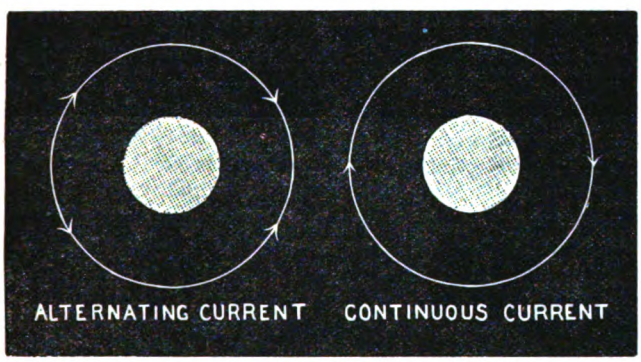

FIG. 3. FIG. 2.

Yet people who deal with optics and astronomy are not expected to be miserable for life because they have that difficulty ever before them. Well, are we to be absolutely unhappy because, while we see a mobile wire caused, in virtue of an electric current through it to move by electro-magnetic force, we cannot see any possibility of explaining how a medium capable of the "magnetic stress" can allow it to move? After all, great as the mystery there is, there is a mystery greater than that. The act of free will with reference to the laws of matter is a greater mystery than anything that has ever been suggested or imagined in the dynamics of ether, and electro-magnetism, and light (applause). Somehow or other, however it is, the ether is pulled round, the ether does get a turning motion in the interior of a solenoid; somehow or other it does give a turning motion to ether within our supposed copper core; and somehow or other there is a motion following these very laws we have been speaking of, and illustrated by the viscous fluid analogy.

But now for the iron. And now, instead of an alternating current through the helix, take a constant current through it. What can it do? One thing or the other it does: either a constant current through this helix drags the ether round and round inside, or it drags it round to a certain angle proportionate to the strength of the electric current, and brings it to static equilibrium so turned. It does either one or other of those things. Now, how on earth can iron differ, in the principle of the interfacial law, from copper? Our interfacial law depending on equal viscosities is quite clear, but when you introduce iron you introduce an interfacial difference depending on rotation, without anything that could possibly be a cause of any viscous action, or a cause of any elastic action. Elastic action (unless of compression or rarefaction, and these are not of our present subject) requires distortion. You have no elasticity of an incompressible elastic solid without distortion. Now if, by applying a tangential force all round the space within a cylinder, you keep turning the circumference, you will keep turning the contents. Ultimately the whole fluid within will go round with the same angular velocity as the circumference of the viscous fluid within it. Thus, our viscous fluid analogue works out perfectly well for the magnetic force within a solenoid having any non-magnetic material within it, and illustrates the fact that it is the same for conducting and non-conducting matter. But with iron the case is something quite different. Our viscous fluid analogue is called on to give us a greater permanent angular velocity, or a greater static rotational displacement, in the space occuped by iron in the magnetic analogue, than in this surrounding space! Thus, the primary phenomenon of the magnetisation of a bar of iron within a helix absolutely leaves us behind, cuts the ground from under us, both as to our viscous fluid analogy and our elastic solid analogy. If it is to be a fluid going round and round, we must have an action between the portions of fluid on the two sides of the interface, depending not on distortion but on rotation. Or if we take our elastic solid analogue, we must have static equilibrium of the elastic cylinder with the inner part turned through a greater angle than the rotational part of the displacement of the surrounding matter. An irrotational circular displacement subtracted from this procures fulfilment of the *no slip* condition at the interface. The distortion due to this irrotational displacement gives rise to a torque, tending to turn the matter within the interface! Hence, we must have an arrangement of matter in which a constant torque produces a constant angular displacement in a body, and does not produce continued rotation. The only thing that can do that is an inherent rotation existing in the molecules of matter. This seems the only thing that can do it, and this *can* do it certainly. But consider this, that the gyrostat shows us the thing done, and I will just conclude, if you will allow me, by a simple gyrostatic experiment—a very well-known old gyrostatic experiment—and I want to accentuate the application of it.

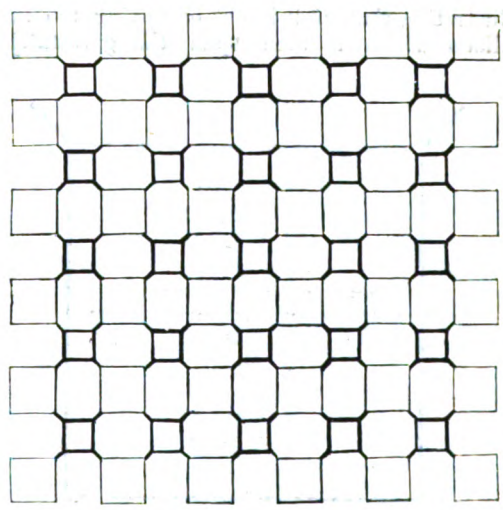

FIG. 4.

I am going to show by this illustration, with reference to the idea of a medium, a medium which has the properties of an incompressible fluid, and no rigidity except what is given to it gyrostatically. Here is, so to speak, a molecular skeleton that can give us such a fluid, a set of rigid squares with their neighbouring corners joined by endless flexible inextensible threads, running frictionlessly through holes in the corners, or round pulleys mounted in the corners (Fig. 4.) Here is a model, thus constructed: 36 rigid squares and 25 endless cord segments connecting the corners in this pattern, forming a kind of web. Now, if we take an ordinary cloth web, and pull it in different directions: in the direction

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of the warp and the direction of the woof, you cannot stretch it; but at 45 degrees from the warp and woof you can stretch it very freely. We all understand that. You know how the surgeons take advantage of it in their diagonally-cut bandages. Now here is a web which is equally easily stretchable in all directions, and yet which is of constant area—a constant area for infinitesimal displacements, not a constant area for very great displacements. The circumference of each rigid and of each flexible square is given. Well, now, if you infinitesimally alter the square into a not-square rectangle, or into a rhombus, the area remains sensibly unchanged. The first change of the area is a diminution in whatever direction you stretch it, but that is proportional to the square of the strain, so that you may say, in language of infinitesimals, the area is unchanged. The constancy of the periphery, then, of each of these figures gives rise to and entails the condition of an approximate constancy of the area. Here, then, we have in this skeleton, a two-dimensional working model of a medium which is unchangeable in area, but is freely extensible in any direction, provided you allow it to shrink proportionately in the perpendicular direction. Well, now, let us put a gyrostat into each of those squares (Fig. 5), and you have all that is wanted to fulfil the strange, almost inconceivable, condition for a dynamical model of electro-magnetic induction in iron which I have put before you. I will just make an experiment illustrating that, if it is not occupying too much time. [Sir William Thomson then spun the gyrostat.] I turn

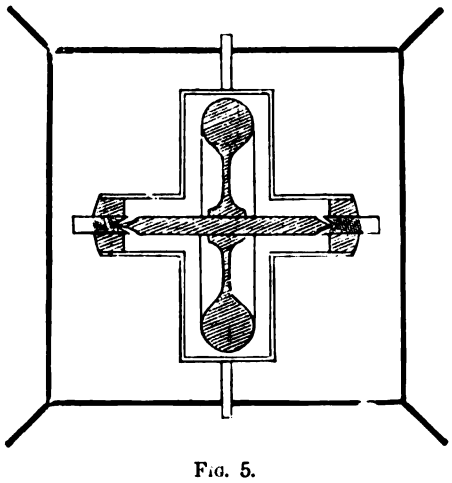

Fig. 5.

azimuthally the square frame by which I hold it; first in one direction, and the red end of the bearing of the axle of the fly-wheel turns up; I turn the other way, and up comes the blue end. The gyrostat is mounted in a square frame, as you see, which I hold in my hand. The rigid case bearing the axle of the fly-wheel is, as you see, free to turn round the axis of these trunnions, mounted horizontally on bearings in opposite sides of the square frame which I hold in my hand. The axis of these trunnions is perpendicular to the axis of the fly-wheel. I shall walk round and round to right, to keep the red side up; I walk round to the left, and it keeps the blue side up (applause). It is rather a curious thing. There are three little objects on a tray, as it were. Imagine this to be a butler's tray, with wine-glasses on it represented by these India-rubber corks. As long as I turn ever so little to my left all goes well; if I go straight forward, it is doubtful; but if I turn by an infinitesimal angle to my right, over it goes and everything falls off it (applause).

Look, now, at the gyrostat resting in this position on its trunnions, the axes of the trunnions and of the fly wheel being both at present horizontal. The outer square frame seems immovable in azimuth. When I apply a couple tending to move it in azimuth it does not move. It does not move in azimuth till the gyrostat turns round its trunnion-axis and brings its fly-wheel axis to be perpendicular to the plane in which I am trying to turn the square frame. And I must apply a couple whose time-integral is equal to double the moment of momentum of the fly-wheel before I can get the gyrostat from the position with the blue end up to the position with the red end up. Before I succeed in turning the square frame even a degree in azimuth I must have applied a torque whose time-integral is equal to twice the moment of the momentum of the fly-wheel.

This closed brass case, with a rapidly-rotating fly-wheel mounted on bearings inside it, is called a gyrostat, because in virtue of rotation it stands, however you place it, with any of its edges resting on a hard, smooth table. You see, place it as I will, it cannot fall. If I place it with its centre of gravity above the supporting point, it stands at rest. With its centre of gravity *not* vertically over the bearing point, it goes round in azimuth, *but it does not fall.*

Now, imagine mounted in each one of the rigid squares of this web a gyrostat exactly as this one is in the square frame which I hold in my hand. If the fly-wheel speed be great enough, each of those rigid squares is practically immovable in azimuth. I do not say it is immovable, but I say you may make it practically immovable by making the velocity of the fly-wheel sufficiently great.

Thus we have a skeleton model of a special elastic solid with a structure essentially involving a gyrostatic contribution to rigidity. Now, do not imagine that a structure of this kind, gross as it is, is necessarily uninstructive. Look at the structures of living things; think of all we have to explain in electricity and magnetism; and allow, at least, that there must be some kind of structure in the ultimate molecules of conductors, non-conductors, magnetic bodies, and non-magnetic bodies, by which their wonderful properties now known to us but not explained are to be explained. We cannot suppose all dead matter to be without form and void, and without any structure; its molecules must have some shape; they must have some relation to one another.

So that I do not admit that it is merely playing at theory, but it is helping our minds to think of possibilities, if by a model, however rough and unpractical, we show that a structure can be produced which is an incompressible frictionless liquid when no gyrostatic arrangement is in it, and which acquires a peculiar rotational elasticity or rigidity, as the effect of introducing the gyrostats into these squares. Imagine a corresponding model in three dimensions, with rigid cubes instead of the rigid squares which you see in the model before you. Instead of the endless flexible cords which you see, you may imagine elastic threads stretched between neighbouring corners of the cubes. In each cube mount three gyrostats, with their trunnion axes perpendicular to the three pairs of its faces. The gyrostatic domination thus provided causes the cubes to be practically immovable in rotation, but leaves them perfectly free to take translatory motion. There you have a body, then, that you could not distinguish from an ordinary elastic solid in respect to any irrotational distortion, or in respect to translational motion of the whole; but which if you try to turn it will not absolutely resist, but will only admit of turning by stretchings of the connecting elastic bands. It will not be immovable in respect of the turning, but it will be balanced by a constant couple with a constant degree of rotatory displacement. Thus, upon this solid the effect of a constant couple is not to produce continued rotation, but to produce and balance a constant displacement, and that balance might last for any time, however long, if the rotational moment of momentum of the fly-wheels is but great enough.

Now, lastly, I should just explain briefly that the rotational contribution to rigidity of ether in iron must be enormously less than in copper or in air. The total effective rigidity of the ether due to elastic action and gyrostatic effect in all non-magnetic bodies is the same. In iron there is less gyrostatic contribution, with equal elastic contribution, to the total rigidity. These conditions fulfil exactly what we want for the relation of ether between air and iron inside the helix of an electro-magnet. But alas! we are only led on to inscrutable difficulties. How much does our elastic solid go towards the explanation when in the very fundamental fact of the mutual motions by which electro-magnetic forces are made manifest to us, we have a force as of a strained solid between the bodies (magnets or wires) whose motions revealed to Œrsted and Ampère the existence of electro-magnetic force? Why is it

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that those strains do not simply balance themselves in the solid? How can there be a solid capable of giving rise to that wonderful condition which we have in the air between the poles of an electro-magnet; for instance—such that a piece of copper will fall down through it at the rate of, perhaps, a quarter of a centimetre per second? Look on the subject as engineers, and think of the "strength of materials" wanted for ether in air, with the molecules of the air itself tearing through it in all directions at speeds averaging 500 metres per second, or more or less according to temperature. Think of the forces, amounting to 110 kilogrammes weight per square centimetre, with which two bars of iron magnetised to 1,700 C.-G.-S., with faces separated by a thin space of air, and with Ewing's 46,000 C.-G.-S. of magnetic force in the air around the bars, are urged towards one another. How can it be that these prodigious forces are developed in ether an elastic solid, and yet ponderable bodies be perfectly free to move through that solid? Now, I simply say all that has been done to think out this subject merely gives us a dynamical theory on one part of it. I have absolutely—not ignored, because I have spoken of it two or three times—but I have left out in the cold the electrostatic part, the thing we knew first. Our first love was electro-statics. That is absolutely left out in the cold. We do not touch it; we do not get near to explaining the mutual force between two electrified bodies in any of these illustrations or attempted explanations. We do not even get near the mutual attraction between the iron of an electromagnet, or the steel of a permanent magnet, and its armature or keeper; we do not get near to explaining the possibility of the motions of the bodies that demonstrate the forces. We only try to explain for a quiescent system of conductors and insulators, the variable distributions of electric currents which from mathematical theory and experimental observation we know to exist.

And here, I am afraid I must end by saying that the difficulties are so great in the way of forming anything like a comprehensive theory that we cannot even imagine a finger-post pointing to a way that can lead us towards the explanation. That is not putting it too strongly. I only say we cannot now imagine it. But this time next year; this time ten years; this time one hundred years, probably, it will be just as easy as we think it is to understand that glass of water, which seems now so plain and simple. I cannot doubt but that these things, which now seem to us so mysterious, will be no mysteries at all; that the scales will fall from our eyes; that we shall learn to look on things in a different way; when that which is now a difficulty will be the only common-sense and intelligible way of looking at the subject. I ask you to pardon me for leading you up to so impotent a conclusion as that we really know nothing below the surface of this grand subject, which constitutes the province of the Institution of Electrical Engineers (loud applause.)

Appendix.

Alternate Currents Through a Straight Conductor of Round or Rod of Non-Magnetic Material:—

Let σ denote the specific resistance in square centimetres per second (or the "specific resistance C.-G.-S.").
a ,, the radius of the wire.
R (S) ,, the value of $\sigma\, l \div \pi\, a^2$ [or the resistance (in centimetres per second) of any length l of the wire, with steady current through it].
R (N) ,, the effective ohmic resistance of the same length, l, with alternate current of N periods per second through it.
c (N) ,, the current-density at distance r from the axis, and at time t.
C (N) ,, the current density in the axis at time t.

We have $c\,(N) = C\,(N)\,(\text{ber}\, q \cos\theta - \text{bei}\, q \sin\theta)$

where q denotes $\left(2\pi\sqrt{\frac{2N}{\sigma}}\right) r$

,, θ ,, $(2\pi N)\, t$,

,, ber and bei denote two functions defined as follows:—

$$\text{ber}\, q = 1 - \frac{q^4}{2^2\,4^2} + \frac{q^8}{2^2\,4^2\,6^2\,8^2} - \&c.$$

$$\text{bei}\, q = \frac{q^2}{2^2} - \frac{q^6}{2^2\,4^2\,6^2} + \&c.$$

And if p denote the value of q with $r = a$, we have

$$\frac{R\,(N)}{R\,(S)} = \tfrac{1}{2}\, p\, \frac{\text{ber}\, p\ \text{bei}'\, p - \text{bei}\, p\ \text{ber}'\, p}{(\text{ber}'\, p)^2 + (\text{bei}'\, p)^2},$$

where the accents denote differential coefficients.

The following Table of Numerical Results has been calculated for me by Mr. Magnus Maclean, official assistant to the Professor of Natural Philosophy in the University of Glasgow.

For copper we have $\sigma = 1{,}610$ square centimetres per second. Hence, with $N = 80$ we find

$$q = 1{\cdot}98\, r \doteq 2\, r.$$

Thus, in respect to the ohmic resistance of the whole wire we may for copper take the column headed q as the diameter of the wire, and in respect to the distribution of the current through the wire (expressed by the ber bei formula above) we may take q the diameter of the cylindric shell in which the current density is to be calculated.

After the delivery of the Address,

GENERAL WEBBER moved "That the cordial vote of thanks of the Institution of Electrical Engineers be accorded to Mr. Edward Graves for the admirable manner in which he has discharged the duties of President of the Society of Telegraph-Engineers and Electricians during the past year." They expressed their thanks to Mr. Graves for the splendid way in which he had filled the President's chair. He had long ago distinguished

TABLE OF NUMERICAL VALUES.

q	ber q	bei q	ber′ q	bei′ q	$\frac{\text{bei}'\,\text{ber} - \text{ber}'\,\text{bei}}{\text{ber}'^2 + \text{bei}'^2}$	$\frac{1}{2}\, q \times \frac{\text{bei}'\,\text{ber} - \text{ber}'\,\text{bei}}{\text{ber}'^2 + \text{bei}'^2}$
0·0	1·0000	0·0000	0·0000	0·0000	∝	1·0000
0·5	·999	0·0625	− 0·0078	0·24992	4·0000	1·0000
1·0	·9844	·2496	− ·062446	·499947	2·00014	1·0001
1·5	·9211	·5576	− ·210011	·730251	1·3678	1·0258
2·0	·7517	·9723	− ·4931	·9170	1·0805	1·0805
2·5	·3999	1·4571	− ·9436	·9983	·9398	1·1747
3·0	− ·2214	1·9376	− 1·5698	·8805	·8787	1·3180
3·5	− 1·1936	2·2833	− 2·3361	·4353	·8526	1·4920
4·0	− 2·5634	2·2927	− 3·1347	− ·4911	·8389	1·6778
4 5	− 4·2991	1·6859	− 3·7537	− 2·0526	·8279	1·8628
5 0	− 6·2301	·1160	− 3·8442	− 4·3538	·8172	2·0430
5·5	− 7·9735	− 2·7902	− 2·9070	− 7·3729	·8069	2·2190
6·0	− 8·8584	− 7·3348	− ·2931	− 10·8462	·7979	2·3937
8·0	20·9739	− 35·0167	38·2944	− 7·6615	·7739	3·0956
10·0	138·8405	56·3704	51·373	135·23	·7588	3·7940
15·0	− 2969·79	− 2952·33	86·648	− 4089·2	·7431	5·5732
20·0	**47583·7**	**11500·8**	**24325·1**	**41491·5**	**·7325**	**7·3250**

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himself as the chief engineer of the Post Office, and during the past year he had endeared himself to them all by the way in which he had led them on every occasion when they had met together (applause).

Mr. C. E. SPAGNOLETTI most heartily, and with very great pleasure, seconded the vote of thanks. He had had the pleasure of knowing and working with Mr. Graves for very many years, and therefore could speak from personal experience to his excellent business qualifications, and the very ready and the very courteous way in which he dealt with all matters referred to him.

The PRESIDENT then put the motion, which was carried by acclamation.

Mr. EDWARD GRAVES said that when they did him the honour of electing him to occupy the chair which he had so recently vacated, he told them that it was a case of the wrong man in the wrong place, and he had not at all altered that opinion—in fact, if he did the address to which he had listened to-night would have corrected the error. But he had told them also that he would do his best; he had striven to do so. They had had many meetings during the year—many meetings of the Society, many meetings of the Council, many meetings of committees, and especially extraneous matters connected with the Lord Mayor's Committee and the Paris Exhibition. He had attended them all (applause), and now at the end he felt himself an official chief mourner at the deceased Society of Telegraph-Engineers, and he resigned to Sir William Thomson the much-pleasanter task of acting as god-father to the Institution of Electrical Engineers that took its place (loud applause).

Prof. GEORGE FORBES said that he had an extremely pleasing duty to perform in rising at the end of the evening to propose a hearty vote of thanks to their President for the admirable, instructive, and highly interesting address which he had given them, and to ask his permission to let the address be printed in the *Journal* of the Institution (applause). He thought everyone would agree with him when he said that they had that evening had one of those treats which it rarely came to them to enjoy—to hear the exposition from a man of Sir William Thomson's experience and position unfolding to them the result of the labours of his life, putting before them not only his personal recollections in connection with the advance of the science in which they were all so much interested, and in recollection of others who had worked with him, but also giving, as the result of this, advice to the members of the profession, young men and others, as to what subjects to pursue and so forth. In the advancement and development of their science Sir William Thomson had been so intimately connected that all of them felt they were being more closely brought in contact with the past history of their science when it was dwelt upon by him in such an address as he had just given to them; but he thought everyone would agree that what they had to thank him for mainly was the manner in which he had inspired them with some of the enthusiasm which he himself possessed in investigating the deeper problems of electrical science, and the interest which he had made everyone of them feel in trying to understand those brilliant analogies between the physical phenomena which were tolerably comprehensible and electrical phenomena which were rather obscure to them. He believed that he was the only member present who had the felicity to attend the three weeks' course of lectures which Sir William Thomson delivered at Baltimore on the undulatory theory of light, and he could give them some conception of what the feeling of all those who were fortunate enough to attend those lectures was when he said that for three weeks they had an uninterrupted exposition and a similar mode of treating the subject as they had had that evening; and it was a thing so rare that he felt everyone here would appreciate the treat which they had had in listening to the address that evening. Among the audience there were some very young members who had but little knowledge of mathematics, and there were also present among them the greatest mathematicians in the country, and yet he ventured to say that there was not one in the long range of abilities included by the audience who had not learned a great deal and had a great deal of new light thrown upon the subject in the course of that evening (applause); and he was sure that those who had not hitherto appreciated the benefits of mathematical investigation into the theory of such phenomena would be able to see from this address the way in which such a man could, by trying to get deep into the sources of things, be able eventually to apply such knowledge to practical phenomena. He remembered very well in 1874, just after the appearance of Clark-Maxwell's book, Prof. Tait, who took perhaps a too sanguine view of the work, considered that the book settled the whole question as to what electricity was—explained the whole thing. Prof. Tait said that some twenty-five years ago, he thought it was, Sir William Thomson had said to him, "if you will tell me what electricity is, I will tell you everything else," and Prof. Tait said, "Clerk-Maxwell had given us that information, and we must now apply to Thomson for the rest." All that evening they had been listening to Sir William Thomson in his attempts to explain, so far as it was possible at present, what electricity was, and what everything else was, too (applause). He felt quite sure that the vote of thanks which he was proposing would be most heartily agreed to, and that everyone in that room felt, as he did, that they had been listening to an address of a quality which it was almost impossible that they could expect ever to listen to again. They must, however, also thank Sir William Thomson for having come the long journey from Glasgow specially to give them the address, and to have taken the trouble to have been travelling all night for their edification. But it was not surprising that he should take this labour upon himself, when in the hour that he had been delivering to them an address he had been trying to compress the subject which he had been working out almost continually night and day for forty-two years. He begged to propose the motion which he had already read out (loud applause).

Prof. AYRTON said it had fallen to his good fortune—for he deemed it to be a good fortune—to be asked to second this vote of thanks, which he was sure they would all accord with the greatest enthusiasm to their new President. Within the last few months they had had the inestimable privilege of hearing their new President and seeing him in that room in two totally different capacities. A few months ago it was as an electrical engineer that he showed and described to them his most beautiful measuring instruments. To-night it was in a totally different capacity—as a theoretical electrician—that he had charmed them for such a long and interesting time, and it was the marvellous power that he possessed of combining theory with practice that had enabled him to accomplish the work that he had done, and which they all hoped he would live for a long time to continue carrying on (loud applause). They had in this country many engineers; they had also many competent mathematicians, but he ventured to think they had only one who could combine in the marvellous way they knew he had combined theory and practice—in fact, he might shortly say they had but one Thomson (hear, hear). On the previous occasion, when as an electrical engineer he was addressing them, he pointed out how important it was to study theory; to-night, as an electrician, he commenced with the diffidence which had marked all his work by telling them that, if they only became engineers, electricity they could grasp in a few months. He was sure that this thought would be a consolation to all engineers there to sleep on that night, that, if they only came into this room well armed with engineering knowledge, all this purely electrical science they would be able to grasp in a few months. That was a consolation, and he would be very sorry to remove that consolation from them; but at the same time he could not help feeling that this previous knowledge of electricity, if it were sufficiently complete to satisfy Sir William, would be something so vast and so comprehensive in its character as to appal the ordinary practical man. They all knew what a deep debt of gratitude was owed by electrical engineers, and he might say by the whole world, to that wonderful mathematical investigation that their President had touched upon so lightly—that investigation which made submarine telegraphy commercially possible. How Sir Wm. Thomson's pianoforte wire had sounded the deep sea—he meant the ocean, not the musical note (laughter)—was quite familiar to them. How his compass had guided ships to their journey's end was well-known to all the world. He dared say that on some occasions ships had started from a port armed with Sir William's compass on voyages of exploration, not, perhaps, quite knowing where they were going, or what they would find. And that night he had supplied them with another compass—a mental compass—and started them all on a voyage of exploration; and because he could not tell them what was the country that they would arrive at—it might be fifty or one hundred years hence—it did not make that mental compass that he had provided them with the less valuable, or diminish their unbounded feeling of gratitude for its gift (applause).

The motion was put and carried by acclamation,

Sir WILLIAM THOMSON, in reply, said: I thank you all very warmly for the kind manner in which you have received the motion which has been put before you. I thank the mover and seconder for the too kind appreciation which they have shown of my imperfect efforts to speak to you in proper terms this evening. I feel that your electing me to be President of the Institution of Electrical Engineers is really to myself a very great personal kindness, because I believe it was understood that, living as I do at so great a distance, I should not be able to do my duty properly as President, and to be here at all the meetings as I would like to be, or at the greater proportion of the meetings as I certainly ought to be, but only at a comparatively small number. I live four hundred miles away, and, as you know, have incessant occupation at that distance in Glasgow, so that it is practically not possible for me to be here at many of the meetings. I must ask you, therefore, kindly to excuse my inability to do myself the pleasure of being with you continuously, or even frequently, and I must trust to the kind consideration of the Vice-Presidents to take the place that I ought to occupy in the presidential chair. I hope to be present at all the meetings of the Society after the end of our Glasgow University session. If possible, I shall be at some before that time, but I am afraid that if at any it must be at but a very few; and I must ask you to kindly excuse me, and to know that it is simply the necessity of the case. It was necessary for me in fact to let it be known before you did me the honour of electing me, that this would be my case with reference to the important duties of the president of this institution. I may say that as regards the management of the business of the institution, I think none of us need feel any concern at all when we know that it is in the hands of our excellent secretary, Mr. Webb (applause.) He is always alive to the Society's interests, always attentive in carrying out the objects of the institution, and with the very great ability which he has shown we may feel that the management is in excellent hands. Then, with the Council here, in whom you have all such perfect confidence, I think you will not feel that the Society loses anything whatever in my absence. I thought it right that I should make my apology at present, as you have been so very kind to me this evening (applause.)

The Utilisation of Telephone Systems for purposes of Clock Regulation.—An attempt will shortly be made by the electricians of the Berlin Telephone Company to use their telephone wires for transmitting regulating currents to the clocks of the subscribers. Once a day about 5 a.m. all the subscribers' wires will be automatically connected to a central clock, and the time currents will be transmitted; the wires will then be automatically disconnected, and the usual service resumed.

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THE WEST BROMPTON STATION OF THE HOUSE-TO-HOUSE COMPANY.

The West Brompton station of the House-to-House Electric Light Supply Company has been designed and erected by the engineer of the company, Mr. William Lowrie, on the lines of the system of electric distribution worked out by him at Eastbourne. With the set of offices, workshops, testing rooms, engineers' and drawing offices, the station is one of the most complete that has yet been erected in this country. At present it contains three complete sets of engines and dynamo plant, each set capable of supplying 4,000 50-watt incandescent lamps, and the completed station will have a capacity of about 48,000 lamps. The engines are of the horizontal type, and made by Fowler, of Leeds; the boilers by the Babcock and Wilcox Company; and the dynamos, of a special type recently designed by Lowrie and Parker, by Elwell-Parker and Company.

The situation is admirably adapted for a central electric lighting station, the plot of land, which is 470ft. long by 60ft. wide, being bounded on one of its sides by the Metropolitan District Railway, and on two of its sides by the London and Westminster Cemetery. The site is just within the boundary of the parish of St. Mary Abbotts, Kensington, and application has been made to the Board of Trade for a Provisional Order under the Electric Lighting Act to light this parish. Pending the granting of this Provisional Order, permits have been given to the company by owners of private property in the vicinity to lay mains underground, and in accordance with these permits the mains of the company are already laid throughout a considerable area.

The frontage in Richmond Road is taken up by the offices, consisting of public hall, clerks' office, secretary's office, board room, engineers' and drawing offices, and show rooms. The piece of land behind the offices has been utilised for stores, stables, cart-shed, yard, forge, meter, testing room, and engineers' shops fitted for doing all necessary repairs, or work required on installations and roads, ash store, and coal store, engine and dynamo room. The switch and regulating room, the testing room, stores, and office for the engineer in charge, are situated in the centre of the station; the latter being upstairs, and having windows on each side, has a full view of the works in both directions. Starting from these buildings, on the one side are the boilers, and on the other side the engines and dynamos.

The Dynamo Machines.—The alternate-current dynamos, one of which is illustrated in Fig. 1, are of a novel type. Running at 380 revolutions per minute the machine has an output of 100,000 watts. The mean speed at which the armature conductor is passed by the field-magnets is about 6,000 feet per minute, and the number of alternations 5,000 complete phases per minute; the E.M.F. is 2,000 volts. The armature, which is stationary, is built up on an iron core of large section composed of charcoal iron sheets thoroughly insulated from each other, arranged longitudingly and in the same plane with the magnetic fields; the conductor at full load carries 2,000 amperes per square inch of section.

The armature coils are formed of narrow tape, each wound in a plane (or slightly curved to suit the radius) upon a piece of insulating material of the same thickness as the width of the tape, and rounded at the ends. The coils are thus of a flat link shape, the edges of the tape windings being exposed upon the flat surfaces of the coils, and therefore well able to resist deflection. These coils are placed close together upon the cylindrical inner surface of the armature ring, so that the axis of each coil is radial to the ring. They are secured by rebated strips of wood, screwed to the cheeks, and extended over the ends of the coils, outside the line of travel of the magnets. By this mode of construction the whole of the conductor (except a small portion at the ends of the coils parallel with the line of travel of the field) is placed under exactly the same inductive influence, and at the same distance from the moving poles, and consequently in the best position for efficiency.

Another great advantage is that no special means are required to keep the conductors from sagging or lifting from their normal position, and thus the clearance space is reduced to a minimum. Furthermore, as the armature coils are simply secured to the face of the armature, they are easily removed

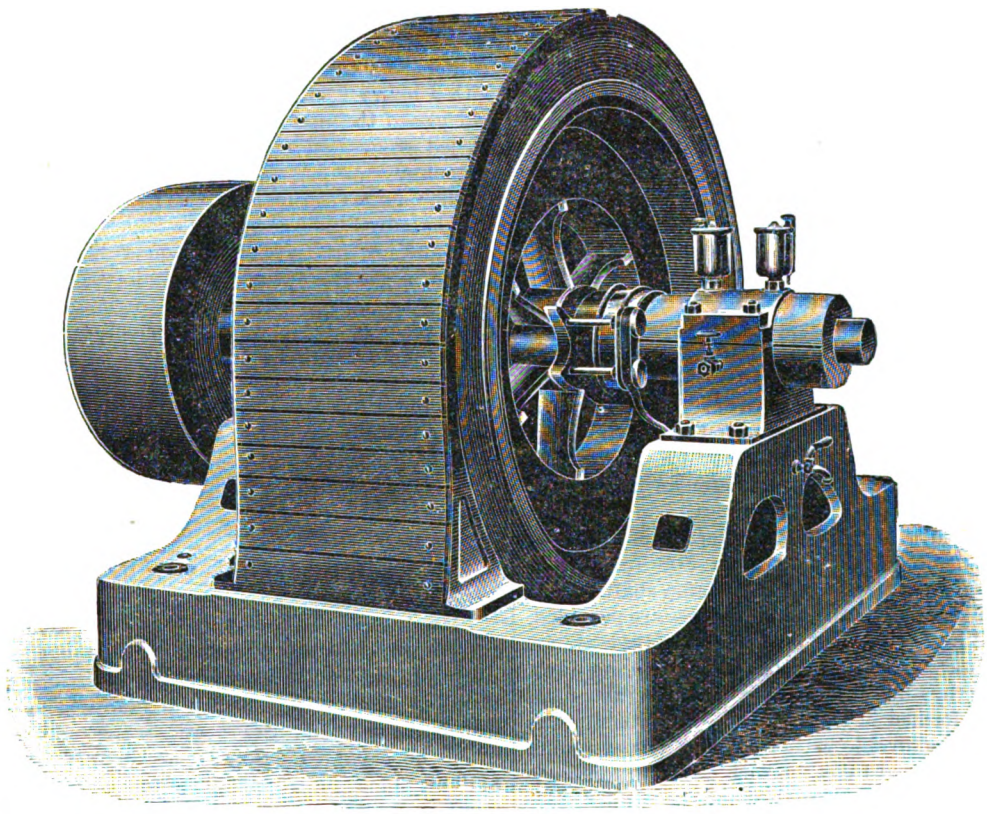

FIG. 1.—THE LOWRIE-PARKER DYNAMO. It will be noted that this machine is shown with a belt pulley, but the dynamos at the West Brompton Station have pulleys for rope gearing.

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or replaced as required. The armature ring is parted upon the horizontal line, so that the upper half is removable for inspection or repairs. The frame for supporting the laminated iron armature core is cast separate, and securely bolted to planed facings.

The revolving field consists of a solid soft wrought-iron ring, with pole-pieces securely attached thereto, and is arranged so that the centrifugal force of the whole of the moving parts is taken by the ring. The energy absorbed by the field does not exceed 5 per cent. of maximum ontput. The base-plate is of box-pattern, and strongly ribbed and under flanged where it bears on the slide rails. The plummer blocks for the bearings are cast separate from the base-plate, and secured by bolts, and lugs, and wrought-iron wedge keys.

The bearings are two in number, 20 inches long; they are in halves jointed on the horizontal centre and fitted with loose brasses, top and bottom. These brasses are of hard phosphor bronze. The bottom brass is so arranged that it can be removed without lifting the shaft, and yet well secured sideways; each bearing is fitted with two combined syphon and sight-feed lubricators. Each end of the bearing is provided with oil catchers, consisting of a chamber all round the shaft, by which the oil passing from the bearings is caught when thrown from the oil throwers provided on the shaft, and conducted by a passage formed in the plummer block under the brass to a waste oil tank or receiver formed in the plummer block or the base plate; each tank is provided with a drain cock fixed in suitable position for drawing off the waste oil.

The shaft is of best mild steel, 6 inches in diameter, the side thrust being taken by collars, forged solid on the shaft at each side of one bearing only; double grooves are cut for throwing the oil into the collectors provided at each end of the main bearings. Mounted on this shaft is a hub of cast iron, attached to the ring on which the magnets are mounted in such a manner as to prevent any magnetic short-circuiting. The rings on the shaft for collecting the exciting current are insulated from the shaft and from each other by ebonite washers. The brushes and holders are supported from the base plate. The driving pulley is of cast iron, double web type, with turned grooves for seven 1½in. cotton ropes, diameter 40in. Fixed to the dynamo is also a pulley of suitable diameter for driving the exciter, turned with grooves for four ¾in. ropes.

The exciter is a 12-unit series-wound inverted machine by Elwell-Parker, with drum armature, run at 800 revolutions per minute, and driven by ropes from the dynamo shaft.

Efficient means for tightening the driving ropes are provided, consisting of two cast-iron rails of heavy section, fitted at one end of each with forcing screws; provided with holding-down bolts for the dynamo, the nuts of which are of rectangular form and sliding in grooves formed in the rails. The bolts being thus applied from above are removable without lifting the dynamo. The two rails are securely tied together with cast-iron distance pieces. Similar arrangements are supplied for the exciter.

The approximate weight of the dynamos is 10 tons, and of the exciter 1 ton.

All around the dynamos and exciters is a highly insulated platform of crossed floor boards set on joists, with bitumen between the two sets of boards and linoleum laid throughout. This platform is raised 6in. above the general floor line.

The Engines.—The machines are each driven by a horizontal coupled compound engine, specially designed and made to specification by Messrs. John Fowler and Co., Leeds, capable of indicating 200 horse-power on the brake at its most economical load; steam being cut off from the high-pressure cylinder before the piston has completed more than one-third of its stroke. The high-pressure cylinder has a diameter of 15 inches, and the low-pressure cylinder is 25 inches in diameter. The stroke is 30 inches, and the initial steam pressure 150 pounds per square inch. The speed is 88 revolutions per minute. Both cylinders are steam jacketed, and are fitted with separate liners. All the cocks on each cylinder are joined together by rods and levers, and brought, with handle, within easy reach of the man standing at the starting valve. Cylinder lubricators are fitted to both valve chests, and an extra sight-feed cylinder lubricator is fitted to high-pressure steam chest. The low-pressure cylinder is fitted at both ends with automatic relief valves; both valve chests are provided with a seven inch steam pressure gauge and cock. The steam feed is from above, and the exhaust is from the bottom side of the low-pressure cylinder. The pistons are of cast iron, with cast iron rings and Junk rings, and Pollet and Wigzell's springs behind the rings; the piston rods are of steel, separate from the cross heads, and secured to them by cotters. The connecting rods are made of best hammered scrap iron, polished and fitted with large adjustable brasses, marine type at crank ends; the gudgeon pin on cross head is forged scrap iron, with means for taking up wear; the length of the rods between centres is 2½ times the stroke of the engine.

The crank shaft is of best mild steel, 8in. diameter in the bearings and 12in. diameter where the key ways for the fly-wheel or pulley are cut. The crank disc at each end is of cast iron, and shrunk on to crank shaft and secured with a key. The crank pins are of steel, slightly conical to fit into the disc, keyed and pressed into place by hydraulic pressure, and riveted into position. The lubrication for each crank pin is effected through the centre of the crank pin and a pipe carrying a receiver revolving concentrically with the crank shaft, this being supplied with oil from a sight-feed lubricator, fixed to the base plate. A main bearing, 16in. in length, is cast in one piece with each base plate, and fitted with brasses of gunmetal arranged for top and side adjustment. Each engine is fitted with a heavy fly-wheel, 14ft. diameter, made in halves, planed and joined through the centre, turned on the edges, and with turned grooves on the face, for driving with seven ropes, 1½in. diameter.

The engines are fitted with Hartnell's governor, driven from the shaft by four cotton ropes, which acts directly on both the high and low pressure expansion valves, and gives a range of cut off in the high-pressure cylinder from 1 per cent. to 60 per cent. of the stroke. It governs the engine to within 2 per cent. A complete set of indicating gear is fitted to each cylinder. The approximate weight of engine is 24 tons.

[Owing to the pressure on our space we are compelled to defer a description of the remainder of the equipment until next week.]

(*To be continued.*)

REVIEWS.

Mechanical Drawing; A First Course. (Tracing.) By Geo. Halliday, Instructor at the City and Guilds Technical College, Finsbury. (E. and F. Spon, London and New York.)

Mr. Ruskin once horrified the drawing-masters by recommending the use of ruler and compass until the pupil has learnt to appreciate the niceties of straight lines and curves, when he may be safely trusted to draw them accurately without such aids. Instructors of mechanical drawing in many a college and institute may possibly be equally scandalised at the novel departure which Mr. Halliday, who occupies a similar position in the Finsbury Technical College, has struck out by the advocacy of a course of tracing exercises leading up to, instead of following, the art of mechanical drawing and design. Neither the Education Code nor South Kensington offers the slightest encouragement to science schools and colleges teaching this very A B C of mechanical drawing; and the result is that pupils very generally begin their course of instruction, so far as scientific drawing is concerned, at the wrong end. Mr. Halliday insists that the same method be adopted in the class room as prevails in every practical drawing office; and the book before us contains a series of progressive examples as a first course, with instructions for the pupils' guidance whether under a master or not. It is to be desired that Mr. Halliday's method and his vindication of it should be known to every science teacher in the kingdom.

BOOKS, &c., RECEIVED.

"The Phœnix Fire Office: Rules for Electric Light Installations and Electrical Power Installations." (14th Edition.)

"General Report of the Minister of Public Works from 30th June, 1867, to 1st July, 1882." (Ottawa: Maclean, Roger and Co.)

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THE HOOKHAM ELECTRICITY METER.

In describing the central lighting station at Leamington (*The Electrician*, August 17, 1888) we promised at a later date to describe in detail the very ingenious meter devised by Mr. Hookham, which has been in use at Leamington since January, 1888; this promise we now fulfil. The most striking peculiarity of this meter is to be found in the remarkably slow rate at which it can revolve without losing proportionality. It has, therefore, a wide range, one size measuring from ·4 to 20 amperes, and another from ·6 to 40 amperes. The loss of energy in this case is only about one-tenth per cent., but where a somewhat higher rate of loss of energy is not objected to—as, for instance, for station service—a range of as much as from 1 to 250 can be obtained.

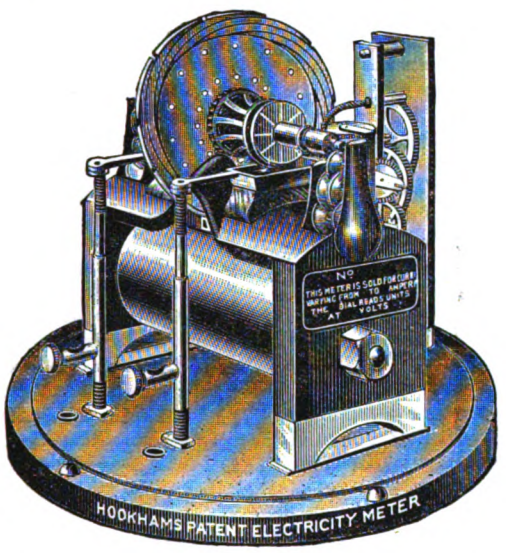

FIG. 1.

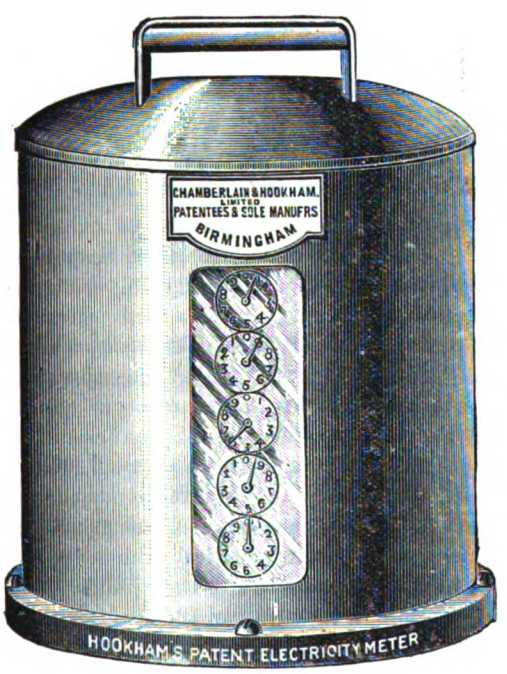

FIG. 2.

The meter consists essentially of an electro-motor doing work against Foucault currents, under conditions in which other retarding influences are negligible. When this is the case, and the armature carries the current to be measured, the field remaining constant, the speed of the armature will vary directly as the current. For the work done is proportional to the square of the speed; the brake-force varies as the speed; hence the speed will be proportional to the driving force, which, again, in a constant field is proportional to the current to be metered.

The engraving (Figs. 1 and 2) illustrates a meter for a thirty-light installation. The armature sections are built up on a copper disc, the connections passing spirally round the edge of the disc. The disc and armature rotate together between the poles of the magnet. These are of cast-iron, the magnet bars of tungsten steel being contained in a brass tube beneath. The reduced ends of the armature spindle roll on the uppermost wheels of anti-friction trains, and a commutator in which mercury contacts replace spring brushes, and which is practically frictionless, is an important part of the device. Iron is not used in the armature, so that magnetic drag does not enter as a disturbing cause. The motions of a worm-wheel driven by a screw-thread on the armature spindle are transmitted to the counter. At present the magnets are fitted with a short-circuiting bar, whose distance from the cast-iron arms of the magnet can be adjusted. The object of this arrangement is that if the field is found to fall off it can be reinforced by removing the bar to a greater distance. In practice this has proved to be a superfluous precaution, as, after many months' testing of a considerable number of meters, in no case is there the slightest indication of the field falling off. The cause of this constancy of field is no doubt to be found in the fact that the air-space resistance is extremely small, and the magnetic circuit consequently almost closed. A further advantage of this closed circuit is that it is impossible to tamper with the field by means of external magnetism, especially as the whole apparatus is enclosed in a stout iron case. This case is glazed at the part opposite the dials, and need not be removed, even at the quarterly visits of the meter inspector.

This meter is at present made for continuous currents only, but the principle would seem to be equally well adapted for alternating currents.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, February 1st.

ROYAL INSTITUTION.

9 p.m. "The Life History of a Marine Food Fish." By Prof. W. C. MCINTOSH, M.D., F.R.S.

MONDAY, February 4th.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. First Ordinary Meeting for the year 1889, at the Town Hall, Westminster. Inaugural Address by the President, Mr. Jonathan R. Baillie.

TUESDAY, February 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

SOCIETY OF ARTS.

8 p.m. Applied Art Section, "Manufacture of Sevres Porcelain." By EDOUARD GARNIER.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussions on the Papers read at the last Meeting. Time permitting, a Paper will be read on "Some Canal, River and other Works in France, Belgium and Germany," by L. F. VERNON HARCOURT, M.A., M.I.C.E. At this Meeting the monthly ballot for members will take place.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture, "Torpedoes." By Prof. A. W. REINOLD, M.A., F.R.S.

WEDNESDAY, February 6th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Status of the County Council." By G. L. GOMME, F.S.A.

THURSDAY, February 7th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Metamorphoses of Minerals." By PROF. J. W. JUDD, F.R.S.

FRIDAY, February 8th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Flexible Wheel-Bases of Railway Rolling Stock." By G. D. TWINEBERROW. Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Electrostatic Measurement." By Sir WILLIAM THOMPSON, F.R.S.

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The Electrician.

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All letters intended for insertion in "THE ELECTRICIAN," *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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"THE ELECTRICIAN" *is on sale at the railway bookstalls throughout the United Kingdom on Friday morning, and can be obtained of all Booksellers and Newsvendors; or direct from the Publishing Offices as above.*

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Owing to the increase in the number of pages of "THE ELECTRICIAN," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

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TO ADVERTISERS.

"THE ELECTRICIAN" *offers exceptional advantages to Advertisers.* **It has the largest circulation of any English Electrical paper, and circulates all over the World.**

Particulars relating to Advertisements will be promptly forwarded on application to this office.

TRADE ADVERTISEMENTS *intended for the current issue must be handed in not later than First Post on Thursday morning.*

SMALL PREPAID ADVERTISEMENTS *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

TECHNICAL PRINTING.

"THE ELECTRICIAN" PRINTING AND PUBLISHING COMPANY (LIMITED) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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Early in each year is issued "THE ELECTRICIAN" ELECTRICAL TRADES' DIRECTORY AND HANDBOOK. *The* DIRECTORY *was established in 1888, and has now attained considerable proportions. Every care is taken to make the names and addresses of all persons engaged in the Electrical Industries absolutely accurate. Useful Tables and Electrical Formulæ are given, together with popularly-written Biographical Notices of the leading Electricians, Electrical Engineers, &c., accompanied in many cases by Portraits.*

THE DIRECTORY for 1889 will BE READY NEXT WEEK

CONTENTS OF THE CURRENT NUMBER.

NOTES 357
Electrical Traction on the City of London and Southwark Subway 362
The Institution of Electrical Engineers.—Sir Wm. Thomson's Presidential Address. Illustrated. Concluded 362
The West Brompton Station of the House-to-House Electric Company. Illustrated 367
REVIEWS 368
The Hookham Electricity Meter. Illustrated 369
Meetings of Scientific Societies. 369
UNDERGROUND WIRES IN NEW YORK 370
Electric Meters for Central Stations. Illustrated 371
Physical Society—
"A Relation between Magnetisation and Speed in the Dynamo Machine." By Prof. S. P. Thompson 374
"The Divergence of Electromotive forces from Thermochemical Data." By Prof. E. F. Herroun 374
LEGAL INTELLIGENCE—
In re Gaulard and Gibbs' Patent.—Appeal. 375
American Notes 376
CORRESPONDENCE—
The Physiological Effects of Alternating Currents.—H. Newman Laurence 378
CORRESPONDENCE—*Continued.*
Telegraphy without Wires.—A. A. Campbell Swinton and F. Higgins 378
Alkaline Accumulators.—P. Bedford Elwell and W. Worby Beaumont 378
The Aurora Borealis.—W. M. Mordey 379
Constant Current Regulation. Alexander Bernstein 379
Red Wire *versus* Black.—Drake and Gorham 379
Ether Resistance.—N. G. Thompson 379
Ether, Electricity, and Ponderable Matter.—O. C. D. Ross 380
The Institution of Electrical Engineers.—"A Provincial Member" 380
PATENT RECORD 380
COMPANIES' MEETINGS, &c.—
Eastern Telegraph Company (Limited) 381
The Direct United States Cable Company (Limited).. 383
Metropolitan Electric Supply Company (Limited)..... 384
Anglo-American Telegraph Company (Limited)..... 384
Cuba Submarine Telegraph Company (Limited)..... 385
Taunton Electric Lighting Company (Limited)..... 385
Companies' Share List..... 386

SPECIAL NOTICE.

The last number of "THE ELECTRICIAN" contained a Steel Plate Portrait of Sir WILLIAM THOMSON, F.R.S., President of the Institution of Electrical Engineers.

A few copies of The Portrait, on large Paper, neatly framed in Brown or Black, will be supplied (carriage paid) for Four Shillings and Sixpence.

UNDERGROUND WIRES IN NEW YORK.

IT was inevitable that the question of overhead electrical wires would come up for discussion some time this year, and the remarkable activity of electric lighting business under the new Act has, no doubt, precipitated a fresh attempt at settlement. As reported in our last week's issue, a committee has been formed by the Board of Trade, in conjunction with the Institution of Electrical Engineers, to report upon the subject, and this committee will probably command as much confidence as any body of men that could have been selected. Moreover, their labours will be materially lightened by the fact that the evidence of the Parliamentary Committee taken three or four years ago, and the still more practical evidence from experience in the United States, are ready to their hands. The action of the Board of Trade in thus calling in the aid of expert advisers may be taken as an indication that it is not disposed to exercise the powers it already possesses in a hasty or high-handed fashion; and we may assume with confidence that the Institution of Electrical Engineers will not lend itself to recommendations which would unfairly hamper the industry with which it is so closely associated, and for the free development of which the public have evinced so much anxiety.

It may be assumed that while the committee is in existence opportunity will also be taken to consider the even more important question of underground wiring. In this connection the Report of the New York Board of Electrical Control, pub-

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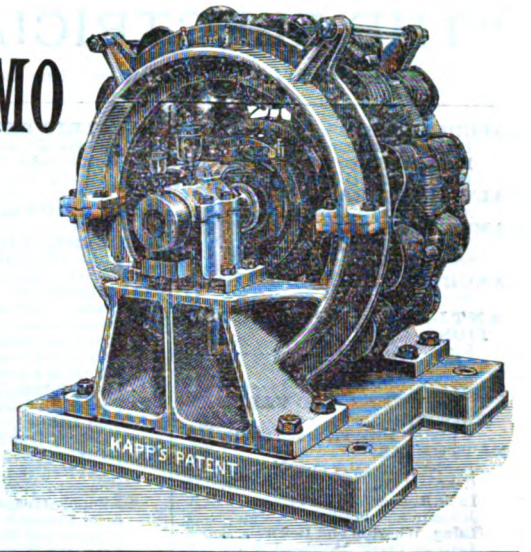

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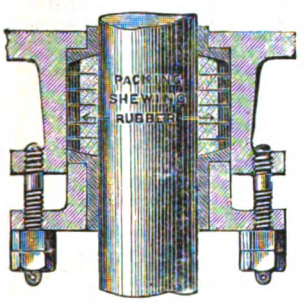

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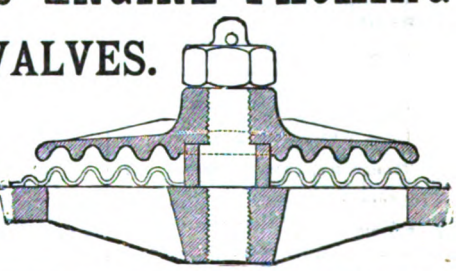

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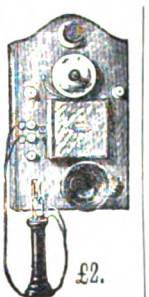

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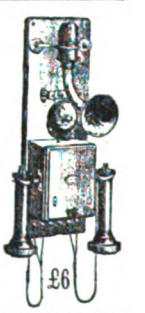

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"THE ELECTRICIAN" INDEX TO ADVERTISERS.

Advertisers in "The Electrician" have their names inserted under the following headings in this Index FREE OF CHARGE.

ACCUMULATORS. PAGE.
Drake and Gorham 6
Electrical Power Storage Co. .. 21
Elwell-Parker (Limited) .... –
ALTERNATORS.
Anglo-American Brush Co..... 17
AMMETERS.
Nalder Bros. and Co. ..... —
Sharp and Kent 13
ANCHOR & SHIPS' SMITHS.
Moore (W. and E.) 18
ANTI-FOULING COMPOSITIONS.
Kirkaldy (J.) and Son 18
ASBESTOLINE.
Bell's Asbestos Company 22, 23
AUCTIONEERS AND VALUERS (Mechanical).
Wheatley Kirk, Price and Goulty 3
BATTERIES.
Fowler, Lancaster and Co..... 3
Gent and Co. 16
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
Latimer Clark, Muirhead & Co. 1
BATTERY JARS.
Joseph Bourne and Sons 2
Cannington, Shaw and Co..... 7
Gent and Co. 16
Price, Sons and Co. 17
South Yorkshire Bottle Co. 2
J. Stiff and Sons ..... —
BELTING.
Balderston and Co. 17
Moseley and Sons 8
Thompson and Rew 7
CABLE COMPANIES.
Anglo-American Telegraph Co. 25
Direct United States Co..... 25
Eastern Telegraph Co..... 26
Eastern Extension Telegraph Co. 26
Indo-European Co. 24
CABLE SUPPLIES.
Latimer Clark, Muirhead & Co... 1
Elliott Brothers 17
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
R. Johnson and Nephew..... 2
Johnson and Phillips 1
Pirelli and Co. ..... —
M. Theller and Sons 3
CARBONS.
Anglo-American Brush Co. 17
Barnsley Carbon Co..... 3
Belfast Electric Appliances Co.. 4
General Electric Co. 13
India Rubber & GuttaPercha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
C. A. Müller 3
Thompson and Rew (Carré) 7
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —
CUT-OUTS.
Electric Apparatus Co. 2
General Electric Co. 13
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —
CYCLOSTYLE.
Facsimile Apparatus Co..... 385
DISINFECTANTS.
Sanitas Co..... 16
DYNAMO MANUFACTURERS.
Allen and Co. 15
Anglo-American Brush Co. 17
Clarke, Chapman, Parsons & Co. 9
Latimer Clark, Muirhead & Co.. 1
Crompton and Co. (Limited).... 12
Edison & Swan United Electric Light Co. 5
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
Gülcher (New) Electric Light and Power Co..... 13
W. T. Henley's Teleg. Works Co. 1
M. Immisch..... 19
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
Laurence, Paris and Scott (Ltd.) 19
Paterson and Cooper 2
Sharp and Kent..... 13
Statter and Co. 2
Telegraph Manufacturing Co. .. —
Thompson and Rew 7
United Electrical Engineering Co. 386
Western Electric Co. 19
EBONITE & VULCANITE.
Harburg India Rubber Co. ..... —
D. Moseley and Sons 8
ELECTRIC BELLS.
General Electric Co. 13
Gent and Co. 16
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 7
London Electric Wire Co. 2
Julius Sax 2

ELECTRIC BELLS—(*cont.*). PAGE.
Western Electric Co. 19
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —
EDUCATIONAL.
School of Electrical Engineering —
ELECTRIC LIGHT.
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co..... 2
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 12
Drake and Gorham..... 6
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 21
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
Gent and Co. 16
Gülcher (New) Electric Light and Power Co..... 13
W. T. Henley's Teleg. Works Co. 1
House to House Electric Light Supply Company 4
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 7
Laing, Wharton and Down (Thomson-Houston) 2
Paterson and Cooper .....
Schmidt-Douglas Electric Co. .. 3
Statter and Co. 2
United Electrical Engineering Co. 386
Woodhouse and Rawson (Ltd.).. —
ENGINEERS & CONTRACTORS
Allgemeine Elektricitäts-Gesellschaft, Berlin 3
Allpress and Belshaw ..... —
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co.... 2
Booth, Ellson and Co. 11
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 12
Drake and Gorham 6
Edison and Swan United Co.... 5
Electrical Power Storage Co. .. 21
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 7
Laing, Wharton and Down 2
Laurence, Paris and Scott (Ltd.) 19
Nalder Bros. and Co. ..... —
Paterson and Cooper 2
Phillips Bros. 2
Julius Sax 2
Schmidt-Douglas Electric Co. .. 3
Sharp and Kent..... 13
J. S. Starnes and Sons..... 8
Telegraph Manufacturing Co. .. —
M. Theller and Sons 3
Thompson and Rew 7
United Electrical Engineering Co. 386
Verity (B.) and Sons 6
Woodhouse and Rawson (Ltd.).. —
ENGINE PACKING.
Beldam Packing and Rubber Co. 13
Bell's Asbestos Company 22, 23
J. S. Starnes and Sons..... 8
ENGINES.
Bumsted, F. D. ..... —
Crossley Bros. 20
Davey, Paxman and Co. 12
Marshall, Sons and Co. ..... —
Ransomes, Sims and Jefferies .. 7
Richards and Co. ..... —
Robey and Co. 8
Statter and Co. 2
EXCESS ALARMS.
Drake and Gorham 6
EXPANSION SHEETING AND RINGS.
Bell's Asbestos Company 22, 23
FENCING.
R. Johnson and Nephew 2
FITTINGS for ELECTRIC LIGHT
Crompton and Co. (Limited).... 12
General Electric Co. 13
Gent and Co. 16
Johnson and Phillips 1
King, Mendham and Co. 7
Laing, Wharton and Down..... 2
C. A. Müller 3
Telegraph Manufacturing Co. .. —
United Electrical Engineering Co. 386
Verity (B.) and Sons 6
Western Electric Co. 19
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —
FUSES.
Fowler, Lancaster and Co. 3
GALVANOMETERS.
Nalder Bros. and Co. ..... —
GAS LIGHTERS (ELECTRIC).
General Electric Co. 13
King, Mendham and Co. 7
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —
GLOBES. PAGE.
Fowler, Lancaster and Co..... 3
INDIA RUBBER.
D. Moseley and Sons 8
Pirelli and Co. ..... —
INFLUENCE MACHINES.
King, Mendham and Co. 7
INSTRUMENTS.
Latimer Clark, Muirhead & Co. 1
Crompton and Co. (Limited).... 12
Elliott Brothers 17
General Electric Co. 13
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 7
Nalder Bros. and Co. ..... —
Sharp and Kent 13
Statter and Co. 2
M. Theller and Sons 3
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —
INSULATORS.
Joseph Bourne and Son 2
Latimer Clark, Muirhead & Co. 1
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Price, Sons and Co. 17
J. Stiff and Sons ..... —
IRON ROOFS & BUILDINGS.
Francis Morton & Co. 7
IVORY LABELS.
Endolithic Ivory Co. 11
LAMPS.
Anglo-American Brush Co. (Arc and Incandescent)..... 17
Bernstein Electric Co. (Incandescent) 2
Crompton and Co. (Limited).... 12
P. S. Dyer (Edison Incandescent) 2
Edison & Swan United Electric Light Co. (Incandescent) 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
Gülcher (New) Electric Light and Power Co..... 13
Johnson and Phillips (Arc) 1
Laing, Wharton & Down (Edison & Swan) 2
C. A. Müller 3
Statter and Co. (Arc) 2
Sunbeam Lamp Co. 9
United Electrical Engineering Co. 386
Western Electric Co. (Arc)..... 19
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —
LIGHTNING CONDUCTORS.
Gent and Co. 16
Johnson and Phillips 1
King, Mendham and Co. 7
Julius Sax 2
LUBRICANT.
Bell's Asbestos Company 22, 23
MANUFACTURING ELECTRICIANS.
Latimer Clark, Muirhead & Co.. 1
Drake and Gorham 6
Electric Apparatus Co..... 2
Elliott Brothers 17
Elwell-Parker (Limited) ..... —
General Electric Co. 13
Gent and Co. 16
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co..... 7
Nalder Bros. and Co. ..... —
Paterson and Cooper..... 2
Julius Sax 2
Telegraph Manufacturing Co. .. —
M. Theller and Sons 3
United Electrical Engineering Co. 386
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —
MEDICAL ELECTRICITY.
Institute of Medical Electricity. —
MICA.
F. Wiggins and Sons 13
MOTORS (ELECTRIC).
Anglo-American Brush Co. 17
Elwell-Parker (Limited) ..... —
M. Immisch..... 19
Shippey Bros. (Limited) ..... —
NON-CONDUCTING COMPOSITION.
Bell's Asbestos Company 22, 23
PAINT.
Indestructible Paint Co. 24
PATENT AGENT.
J. C. Chapman 3
PLATINA SCRAPS.
Jamieson (W. & J.) 3
PRINTING AND ENGRAVING.
Waterlow and Sons (Limited) .. 6
POROUS CELLS.
Joseph Bourne and Sons 2
Price, Sons and Co. 17
Stiff and Sons..... —

PUBLICATIONS. PAGE.
Alternate Current Transformers —
Dynamo Electric Machines .... —
"Electrical Plant" 3
Electricians' Directory 10
Practical Electrical Measurement 11
Steam Engine Indicator 11
"Telegraph Convention" Codes. 15
REGULATORS.
Shippey Bros. (Limited)..... —
RESISTANCE COILS.
King, Mendham and Co. 7
Nalder Bros. and Co. ..... —
SECOHMMETER.
Nalder Bros. and Co. ..... —
SECONDARY BATTERIES.
Drake and Gorham 6
Electrical Power Storage Co..... 21
Elwell-Parker (Limited) ..... —
SHIPWRIGHTS.
Napier (R.) and Sons ..... —
Turner (N. and K.) 18
SOCKETS.
General Electric Co. 13
SULPHURIC ACID.
Pearce (Wm.) and Sons 16
SUPPLIES FOR CABLE SHIPS
Fritz and Co. 24
F. Lack and Sons 24
Moore (W. and E.) 18
J. S. Starnes and Sons..... 8
Duncan Wallet and Co. 2
SWITCHES.
Crompton and Co. (Limited).... 12
Drake and Gorham 6
Edison & Swan United Electric Light Co. 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
General Electric Co. 13
Sharp and Kent..... 13
Thompson and Rew 7
United Electrical Engineering Co. 386
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —
TELEGRAPH ENGINEERS.
Latimer Clark, Muirhead & Co.. 1
Elliott Bros. 17
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Telegraph Manufacturing Co. .. —
TELEGRAPH PAPERS.
Waterlow and Sons (Limited) .. 6
TELEPHONES.
W. Blenheim and Co. ..... —
Fowler, Lancaster and Co..... 3
Gent and Co. 16
King, Mendham and Co. 7
New Telephone Co..... 13
Stanhope Company ..... —
M. Theller and Sons 3
TOOLS.
Fenn and Co. ..... —
TRANSFORMERS.
Elwell-Parker (Limited) ..... —
Sharp and Kent..... 13
TURNERS.
Samuel Elliott ..... —
VALVE.
Mosses and Mitchell 385
VENTILATING ENGINEERS.
Blackman Ventilating Company. 3
VOLTMETERS.
Nalder Bros. and Co. ..... —
Sharp and Kent..... 13
VULCANISED FIBRE.
Mosses and Mitchell..... 385
VULCANITE.
Harburg India Rubber Co. .... —
D. Moseley and Sons..... 8
North British Rubber Co. 5
WALTHAM NON-MAGNETIC WATCHES.
Robbins and Appleton 4
WIRE (Covered or Uncovered).
Latimer Clark, Muirhead & Co.. 1
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
R. Johnson and Nephew..... 2
Johnson and Phillips 1
London Electric Wire Co..... 2
Midland Electric Wire Co. 16
Phillips Bros. 2
Phosphor Bronze Company 384
Pirelli and Co. ..... —
W. Rickard 16
Telegraph Manufacturing Co. .. —
Wagener and Co. 16
Western Electric Co. 19
WIRE-COVERING MACHINES.
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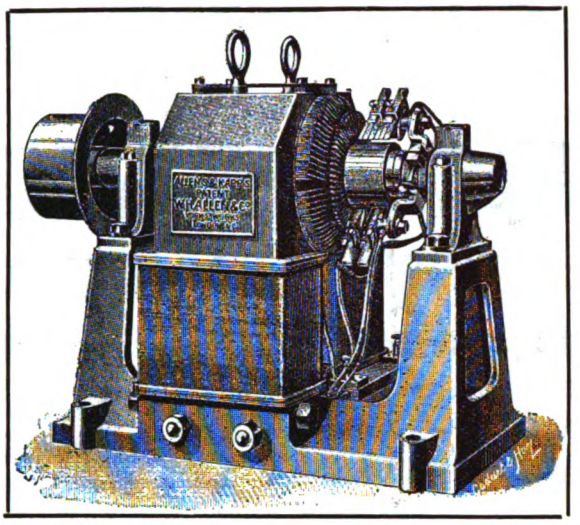

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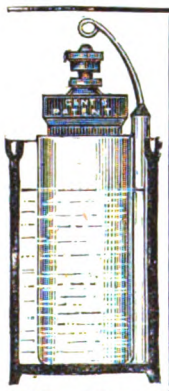

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lished on the 21st of last month, will necessarily have considerable weight; and although the evils which are complained of in this country are not to be compared in magnitude with those which the New York Board has had to contend against, they are pretty much the same in kind. In New York the overhead wires have become not only a public nuisance, but a public danger; and although it is inconceivable that they could grow to a similar extent anywhere in this country, the English are a more fastidious people than the Americans; and we may be thankful, therefore, that the matter is being taken in hand with us at an early stage, so that no drastic and arbitrary remedies may be needed here, as they have been in New York. On this point the experience of the Empire City is a standing warning. Such has been the progress of electrical business there that the construction of underground conduits and subways, although pushed on rapidly by the Board of Control during the past two years, has not kept pace with the requirements of the wiring. The Board is constrained to admit its failure in this respect in the following terms:—"Notwithstanding the fact that there are 4,500 miles of underground conductors in the City of New York, and notwithstanding the removal of a considerable number of poles and wires during the past year, it is safe to say that there are to-day in the city of New York more overhead conductors than there were a year ago." Possibly the true explanation is to be found in the fact that the companies have not yet fully developed their systems in the several areas—a condition which, as we have often insisted upon, should be fulfilled before the mains can be judiciously placed underground in any permanent fashion.

With the election of a new Mayor pledged to support the Board some hopes are held out that its powers will this year be energetically enforced and greater progress made with the underground conduits. As to the powers, no one can complain of their inadequacy. After a ninety days' notice the Board can pull down the poles and wires of any refractory company refusing obedience. But in exercising these powers the Board has been hindered by two considerations besides the personal one already alluded to; namely, the want of funds to pay for the demolition, and the want of sufficient accommodation for the ever-increasing number of exposed wires. Provision on these heads it is expected will be made during the present mayoralty. The conduits, however, themselves have not always come up to the Board's own standard of efficiency, which does not appear to be excessively high. Not only are they open to the criticism of the offending companies, which was to be expected, but they are assailed by water and steam from other companies supplying those commodities, which had never been expected. As regards the water, the Board promises amendment by improvement in construction; and as to the hot steam, if the companies who generate it do not stop the leakage, they will be held responsible for the damage done to the wires. This is all very well by way of promise; but meanwhile, in the matter of performance, the electrical companies prefer to bear the ills they have already rather than fly to others they know not of. In plain words, bad as it confessedly is, the insulation of their overhead wires is under control, whereas the insulation underground is not. That this is the view taken by the electrical companies comes out clearly from an examination of the figures supplied in the Board's report. The lengths of trenches excavated and conduits already constructed are stated in feet—apparently to magnify the undertaking—whereas their capacity for accommodating wires is stated in miles. This is a little perplexing; but comparing the estimated accommodation offered with the actual amount used, we learn that for the telegraph and telephone services room can be found for 34,665 miles of wire. At present there appears to be only 4,250 miles of such wire occupying this vast space. For lighting and power service the "duct conduits" are estimated as sufficient for 600 miles of wire, whereas their actual occupants measure less than 9 miles. It ought to be mentioned here that the Edison Company have 192 miles of underground wire for lighting purposes placed in their own system of conduits. But on the whole it cannot be said that the electric lighting companies of New York have shown the desired readiness to remove their conductors from above-ground; and it still remains to be seen whether the Board of Electrical Control will be able to compel them to do so during the present year.

The Board is on safer ground in dealing with the telegraph and telephone wires. The local evidence it adduces in respect to their safety and efficiency when placed underground can hardly be gainsaid; and it is backed up by similar testimony from Boston and Chicago. But the Report is significantly reticent, or disappointingly obscure, as to the one point on which above all others we would have desired explicit information, namely, the feasibility of laying electric lighting wires on a large scale, and with various methods of working, in these excavated subways. At all events, the experiment has yet to be tried; and at present the New York lighting companies are not contented with the provision made for trying it. This being the case, the Board has wisely devoted a good deal of its Report to framing regulations for wires that remain overhead, and are likely to remain. Among these we may mention one which has at least the merit of being calculated to prevent the unnecessary multiplication of poles. In granting permission for their erection the Board stipulates that they may be used by any other company desiring to do so, and offering proper payment for their use. Of the electrical regulations framed by the Board, they are such as would suggest themselves to any competent committee who may take the matter in hand in this country. We feel sure also that any English committee will act in the spirit, if it does not adopt the language, of the New York Board's Report, where it is urged that as "electrical business is a development of civilisation in its highest form" any interference with that business should be for its "reasonable and proper regulation, not for its retardation or obstruction."

ELECTRIC METERS FOR CENTRAL STATIONS.

At the meeting of the Society of Arts, on Wednesday, the 23rd January, Mr. W. H. Preece, F.R.S., in the chair, Prof. George Forbes, F.R.S., read the following Paper:—

There is no department of electric engineering which has interested me and occupied my thought more than that of central station work and the distribution of electricity from these centres throughout a town for the production of light and motive power.

It was before this Society that I had the honour of classifying and developing the systems of distribution at the disposal of the electrical engineer.* The position in which we now find ourselves is that for extremely concentrated areas a direct supply with continuous-current dynamos, sometimes assisted by secondary batteries, and working on the three-wire system, is the most successful and the most remunerative. That is the result of experience, I think I may say, in all parts of the world. But for extensive areas the use of high-tension alternating currents in our mains, reduced in the houses by means of induction apparatus, is the most economical and flexible. This is the system which was first published and used by Gaulard and Gibbs. To take examples in the city of London. While we prefer the adoption of high-tension alternating currents by a company which is preparing to supply the whole of London with electric light, yet I felt that for the concentrated area bounded by Pall-mall, Green Park, Piccadilly and Haymarket, it was far best to recommend the low-tension three-wire system; and we may safely look forward to seeing that central station, though it is on the low-tension system, certainly one of the most satisfactory in the world from every point of view. This is owing

* Cantor Lectures, 1885.

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to its concentrated area and the large consumption of light in the district.

It always seemed to me that the success of such central stations depends largely on the working out of details in the arrangements, details in the mechanical parts, details in the electrical parts, and I have seldom, if ever, visited any such stations without seeing new points of detail, and learning new facts about the causes which lead to success and failure.

In order that we may make as few mistakes as possible in our central station work, one must try to learn as much as possible from countries which have made a greater start than England. It was for this reason partially that I was led to visit the stations established on various systems in the United States, and lately I have done the same thing with respect to the most important of the central stations in Europe.

Both in Europe and America there is one maxim which I find is conclusively established as the result of practice—this is, that the best paying stations are those in which the electricity is charged for by meter, and not at so much per lamp per annum. Both these systems are in use, but companies who have used both give their unqualified and undivided testimony in favour of charging by meter.

I propose to deal with this important point of detail to-night, and to tell you something about the working of different types of meters in the United States as well as in Europe.

Now first let us settle the question what it is we want to measure. Both with gas and with electricity, if the company supplies burners or lamps, it would be most desirable to measure the light given off. But this plan is not likely to be adopted in England. In other countries it frequently happens that the electric lamps are supplied by the company which is supplying the electricity; but that has not been the case hitherto in England, and I think we may take it as pretty certain that that is not the plan which is going to be adopted. The private consumer in this country will generally supply the lamps as he does the burners for the utilisation of gas. Hence what we come to is that we want to measure the gas or the electricity consumed. We want to measure its light-giving power. To do this we must know the quantity consumed and its quality. With gas, the latter is impossible to measure in the meter. We can only measure the quantity of gas consumed. We cannot by means of the meter measure its pressure nor its purity, nor the quantity of air or sulphur combined or mixed with it. These points are left to inspectors to determine, who shall insist upon a standard being maintained.

With electricity it is different. When we have measured the quantity consumed, there is only one quality which can exist, and that is its pressure. If, then, our meters measure the quantity consumed, and inspectors keep watch to see that the pressure is always maintained constant, the consumer's interests are amply looked after.

Now it has been suggested that we really ought to measure not the quantity of electric current which is consumed, but the quantity of energy. Now the energy is the product of the quantity by the pressure, and could easily be measured if desired. There would be no object, however, in doing this. A deficiency of pressure is certainly undesirable, because the lamps burn less brightly, and the customer would be charged less if such a system were used, and so far the plan would be advantageous. But, on the other hand, an excess of pressure is equally objectionable, because it injures the lamps, and it would not be fair to charge the customer more for the quantity he uses under these conditions. Hence, the energy of the current is not what it would be fair to charge the consumer. The only fair way is to do as with gas, *i.e.*, to measure the quantity used and guarantee the quality, *i.e.*, the constancy of pressure. This should never vary more than 4 or 5 per cent. at the most. For perfect lighting a variation of 2 or 3 per cent. only can be allowed. I trust that in the immediate future, when we certainly expect to see an enormous development of central station lighting in this country, great precautions will be taken to see that the variations of pressure do not amount to a serious quantity. There is too much evidence, I fear, that sufficient attention is not always paid to this point, and I have myself seen in some central stations in this country a very large variation of pressure over the district which is being lighted. I hope that the fault will be thoroughly appreciated in the central stations which are being put down now, in order that we may have less ground for complaint against the electric light.

I intend to direct your attention to various kinds of meters which have been put into actual practice, but before doing so it will be well to point out some of the *desiderata* in a perfect electric meter. I will deal with these in order.

1. *Accuracy.*—The meter must be at least as accurate as an ordinary gas meter; in fact, that standard is rather low for modern requirements (hear, hear). The question of accuracy is twofold. First, the readings of the meter must be accordant with different strengths of current passing through the meter, and for all rates of supplying electricity within its range. These readings should be quite accordant; when we take 10 times as much current out of the meter, we ought to get exactly 10 times as large a reading in a given time. Secondly, the indications of different meters must be consistent. This latter point is largely one of manufacture, and in the construction of some meters it becomes a very important point to see that it is easy to manufacture the instruments in large quantities, and that the different instruments will be exactly similar and quite comparable in their effect.

2. *Range.*—It is desirable that the meter should be capable of working accurately over a large range of current strength. It would undoubtedly be desirable that the meters made for the largest currents which can be used on a circuit should also be capable of indicating correctly when only one lamp is in circuit. So far as I am aware, no electric meter has been invented fulfilling this requirement. It has often been proposed, with circuits of very many lamps, to have two meters—one for small currents and the other for large ones—and to switch in the latter automatically when the current exceeds a certain amount, and to switch it off again when the current falls below that amount. It is perfectly easy to devise electrical apparatus which shall act automatically and in this manner, but at the same time there is a serious objection to any such arrangement which involves an occasional use of a contact breaker, owing to the sparking and consequent deterioration of the contact. A far better plan, and that which is adopted, I believe, in most stations which employ meters, is to wire the houses in separate circuits of 20, 40, 60, or 100 lamps, according to the effective range of the meter adopted, using a separate meter for each of the circuits.

3. *Consumption of Energy.*—Energy must not be consumed by the meter to such an extent as to diminish injuriously the voltage supplied to the lamps. The loss of energy in any meter is likely to be extremely small, regarded simply as loss of energy—as cost of energy. That is a point about which there need be, I should think, no fear. But it is desirable to see that the meter has not sufficient resistance to reduce the voltage of the lamps when the full number of lamps is on. The wiring of a house generally diminishes the voltage at the maximum about 2 per cent., according to present practice in this country. A meter ought not to increase this loss by more than ½ per cent.

4. *Simplicity.*—The meter should be simple to construct, and not liable to get out of order. Extreme delicacy in moving parts is to be avoided when possible.

5. *Durability.*—It is essential that no parts of the apparatus are liable to wear out rapidly, because not only would there be an expense, but it would lead to irregular action of the meter.

6. *Attention.*—Other things being equal, that meter is the best which requires least attention. Any winding up of clockwork is objectionable, and the necessity of removing the meter or part of it from the consumer's premises should be avoided.

7. *Registration.*—The meter should register in a clear manner, so that the consumer can read it at any time and check its accuracy. A system of geared wheels with indexes and pointers, like a gas meter, is very convenient.

8. *Testing.*—A point of some practical value is that it should be an easy matter to test the meter, and that the operation should not occupy much time. We find a great diversity in different types of meter on this head. Some meters which are very slow in producing a single indication require many hours—it may be even a day or so—to test it for the small currents; and to test it over the whole range of the currents occupies many days with some meters.

9. *Cheating.*—With some meters the process of cheating is easier than with others. I speak chiefly of cheating on the part of the consumer (laughter). I notice that generally when I have been speaking about meters with people the other possible way of cheating is not considered of much importance (renewed laughter). The possibility of short-circuiting the meter is common to all, and can be obviated. Some meters can be retarded by placing a magnet near them, others by heating them locally, others by putting them out of level. This last can be prevented by securely fixing the meter to a wall or floor.

10. *Economy.*—Of course, it is very desirable that the meter should not be a very costly apparatus. It will not be practical if it entails a large rental, and so adds much to the quarterly bill.

11. *Freezing.*—A meter which contains a liquid which can freeze is objectionable in any but warm countries, since a lamp or other resistance must then be put inside it to keep it warm, and this is a constant source of waste of energy.

12. *Alternating and Continuous Currents.*—Some meters are only usable with continuous, others with alternating currents. A meter which reads with equal accuracy for both kinds has a double value. Many stations supply both classes of currents, and it is less inconvenient to deal with only one type of meter.

13. *Number of Alternations.*—Meters for alternating currents ought to indicate with equal accuracy, whatever be the alternations per second. Otherwise irregularities will occur, and also the other kind of cheating is likely to come in—that is to say, the supplier of

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electricity can cheat by altering the number when under test, and also when at actual work.

14. *Contact-breaking.*—No contact-breaker of any electric circuit should be allowed in a meter, because such contacts deteriorate with use.

15. The meters should be so substantial that they can be sent by rail without accident. I have here grouped together the 15 principal points which have occurred to me, and I think to others, as the points which have to be considered in relation to electric meters. I have discussed many of these different points with manufacturers in different countries, and I think this list includes pretty well all that have either suggested themselves to me, or which other people have spoken of.

No one meter fulfils all these requirements. But all the meters which I am going to describe fulfil many of them, as they all have done good practical work on central stations. I am not going to make any invidious comparisons between the merits of different meters in what I say this evening. I have put before you the desiderata which are to be obtained, and I feel quite confident that the meters which I am going to describe are all very good meters; and I feel also sure that those meters which fulfil the conditions which I have enumerated most satisfactorily, so as best to meet the requirements of central station lighting, will be the most successful in the future, and will be used most generally. Everyone will see that that is the logical thing, and that it is much better to leave the comparison of the relative merits of different meters to the actual tests of experience, than to dilate on them, except in the most hypothetical sort of manner, at the present stage of electric lighting.

In all the meters which I have to describe the registration is effected either by moving mechanical parts or by electrolytic decomsition. In most of the mechanical meters a certain dynamical principle has been employed to guide the inventor to an accurate instrument for different strengths of current. I will now briefly explain the general idea of this principle, which has helped people very much. In the class of meters I allude to the electric current sets some mechanism in movement. Now we all know that generally the work done by a current in a given time varies as the square of the current. Thus the electrical force tending to drive the mechanism is proportional to the square of the current. Such mechanism would increase its speed indefinitely under the influence of such a force if there were no friction opposing the increase of speed. In the meters I allude to, the friction of the air or of a fluid is opposed to the driving force of the electric current. This resistance increases as the square of the velocity. The electric force goes on increasing the speed of the mechanism until the opposing friction equals the driving force of the electric current. But the friction varies as the square of the velocity, and the driving force varies as the square of the current. Hence, in all cases where the mechanism acquires uniform speed the square of the velocity is proportional to the square of the current; in other words, the velocity varies as the current. Now, the indications of such an instrument as shown by an index gives the number of revolutions of the mechanism in the period of testing, which means the velocity multiplied by the time, and this is proportional to the electric current multiplied by the time. Hence the index marks the total number of ampere-hours, or the total number of Board of Trade units which have passed through the instrument.

Edison Meter.—In describing the different meters, I will begin with the Edison meter, not only because it was the first to be used, but also because it has done a larger amount of useful work in central stations than any other meter. In its original form, as shown in the Paris Electrical Exhibition in 1881, it consisted of two copper plates suspended from the two ends of a balanced beam in a solution of sulphate of copper. A continuous current passing through from one plate to the other decomposed one plate and deposited copper on the other. This one eventually got heavy enough to tip over the balanced beam. This mechanical action had two effects, (1) it registered a unit on the counting mechanism, and (2) it reversed the direction of the current by means of a commutator; and now the current flowing through the solution in the opposite direction, the lighter plate received the copper deposit, and so the process went on continuously. It was not possible to pass the whole current in this way through the solution, because the resistance would be too great, unless we unduly enlarge the dimensions of the apparatus. Hence the depositing cell was put as a shunt on the main current. Several objections to this type soon became apparent in practice. (1) When the temperature of the air was high, the resistance of the solution diminished, while the resistance of the alternative metal path increased. Hence with high temperatures a greater proportion of the total current went through the meter. (2) It was soon found that a make-and-break, as necessitated by the commutator to produce reversals in the direction of the current, led to endless trouble, and the ingenious method of counting had to be abandoned. In the improved meter zinc is the metal employed, and sulphate of zinc the solution. The current always goes in one direction. Fresh plates are inserted as they wear away. These are examined once a month. To determine the consumption of electricity, the meter is carried away and the loss of zinc in the positive plate is weighed, and the consumer charged for a proportionate number of units of electric current; $\frac{1}{1000}$th of the total current passes through the zinc solution. In series with this solution (with the electrolytic cell) is placed a copper resistance, so arranged that with a rise of temperature the fall in resistance of the solution is exactly balanced by the rise in resistance of the copper, the alternative path being of German silver. Thus between 4° and 34°C. the same fraction of the current approximately passes through the solution. To prevent freezing an incandescent lamp is always kept burning in the case containing the meter during the months that freezing is possible. I have, through the kindness of the Edison-Swan Company, an Edison meter here. (Fig. 1.) In the lower division of the case you will notice the resistance in a zigzag form, and underneath that is placed a lamp which is used for the purpose of preventing the solution from freezing. There are holes at the side to allow a certain circulation of the air so that it may be maintained pretty constant in temperature all over. The shunt coil of copper wire is placed behind the upper compartments of the instrument and in series with the electrolytic cells.

The range within which the meter is said to be accurate within 3 per cent. is from fivefold to tenfold, according to the purposes for which it is in use—*i.e.*, if 1 ampere is the lowest current for which it is accurate, then 5 or 10 amperes is the maximum current for which it is accurate, though it will measure, of course, to a certain extent for greater or smaller currents.

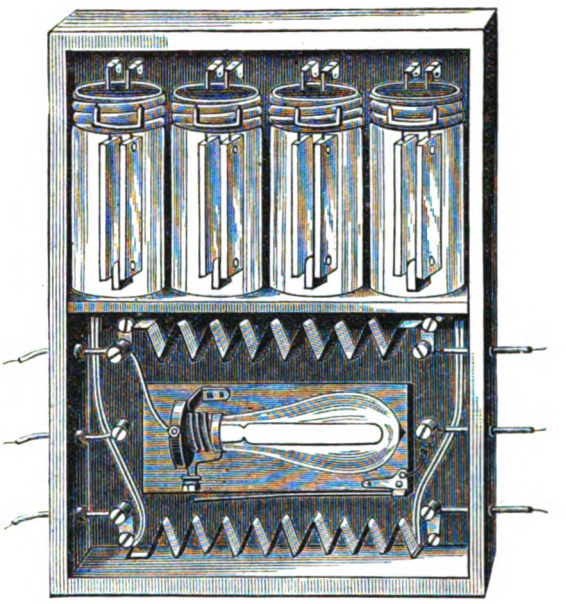

FIG. 1.—Latest Pattern Edison Three-Wire Meter.

Now, you may say that this is not exactly the kind of meter we require, because customers cannot check the weighings and are absolutely dependent on the good faith of the company supplying the electricity. It has also been argued that the shunt arrangement cannot be perfect with varying temperatures. I have heard both of these objections raised frequently, over and over again. I believe that there is a very general impression in this country that the Edison meter is not a satisfactory meter, and is not actually used in practice. I believe that there is a belief among a great number that in stations in America where the Edison meter is used, they never weigh at all, they simply guess at the bills and put them down. This is a total error; the instrument has been used in a very large number of central stations indeed. I agree entirely with every word in the very modest opinion which Mr. Edison expressed to me about it. He said:—"It is not an ideal meter, but it is simple and effective, and gives general satisfaction wherever it is used." I endorse this opinion (applause). But the managers of central stations where it is used have given me higher estimates still of its value. They say that customers are all quite content with the manner of reading it. As to accuracy, many customers have kept accurate tally of the lamp-hours which they have consumed, and compared it with the charges by meter, and have often come within 2 or 3 per cent. At the splendid central station at Milan, which I lately visited, this meter is in constant use, and is much appreciated by the company. They say that the expenses of maintaining the meter department are not large when the whole thing is well organised. The total number of ampere-hours sent out from the station, as measured by the ampere-meters, agrees with the meter

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accounts within 3 per cent. This station, which I have carefully inspected, is an admirably conducted one, and embraces three systems—the Edison low-tension, the alternating high-tension, and the Thomson-Houston arc-lamp systems. I think there is no town in Europe where the electric lighting of the streets is so universally good as in Milan. The Thomson-Houston arc lamps are distributed through nearly all the leading thoroughfares of the town. It is difficult to walk in the principal parts of the town a distance of a few hundred yards without coming in sight of an arc lamp. The result it is needless to speak of to those who have ever appreciated the benefit of a town lighted by arc lamps at night. The charm of that light, when well distributed over a large district, is incalculable. It cannot be described. I remember well four years ago Mr. Preece when he came back from America after the British Association had been over there, describing the depressing effect of driving through London after one had been accustomed to the arc-lighted streets of America (applause). There is an effect on the system which is most marked, which every person who has ever experienced the benefit of living in an arc-lighted town has felt, an effect on the system of having a really pure and good light, not to mention the benefits of arc lighting to all the requirements of a town, and to the orderly manner in which a town is conducted, its cleanliness, and everthing else. I cannot account for the fact that in this country the arc light has been so much neglected in our streets, and I do trust that with the revival of electric lighting, which is coming on now, street arc lighting will be brought within the cognisance of the British public, as it is within the cognisance of other nations all over the world (applause.)

Ferranti Meter (Fig. 2.)—The next meter which I wish to describe is that of Mr. Ferranti. There is a drawing of it on the wall. This meter is so beautifully simple in its principle as to please one at first sight. It is founded on the principle that when an electric current passes through a fluid which is placed in a magnetised space, the fluid tends to move in a direction perpendicular to the current and to the magnetic action. Here is an iron column, D in the figure, with a hollow in its centre,

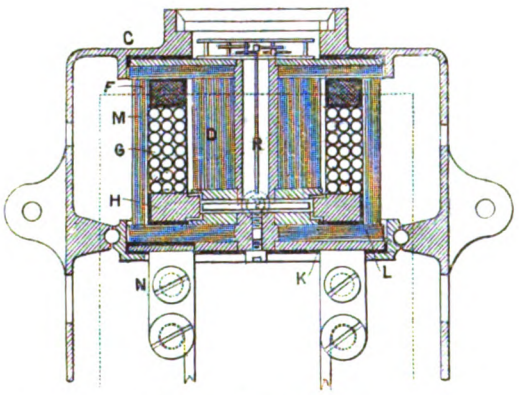

FIG. 2.—Ferranti Meter.

containing a rod, R, on the top of which is pivoted an arbor attached to the counting mechanism. This central iron cylinder is surrounded by wire coils, G, which are shown in section, and round the coil of wire is an iron casing, M. Thus, when an electric current passes through this coil, the central parts have one polarity, we will say North, and the outside casing has a polarity, which in that case would be South. Within the magnetic field is a layer of mercury, H, in which there is an extremely light delicate float attached to the rod R. Mr. Ferranti experimented to a great extent until he attained the shape which was found the most effective and to give the most accurate readings. This float is connected by the rod R with the arbor communicating with the counting mechanism. The current enters at the terminal K, and passes through the mercury to its circumference, meanwhile crossing the magnetic field. It then goes through the coils of wire that surround the magnet and goes out at the other terminal of the meter. The mercury, therefore, has a current passing through it from the centre parts to the periphery, and it is also in a magnetic field, and consequently it tends to move in a direction at right angles to the magnetic action, and at right angles to the direction of the current—that is, the liquid tends to circulate round the central vertical line, and in doing so it sets the float in motion and causes the mechanism to rotate (applause.) I should add, that the shunt coil at F is employed to give the field an initial value independent of the current, and which thus tends to correct for the error introduced by the friction of the wheel train.

The original instruments were intended for currents continuous in direction, and the magnets were excited by the electric current to a moderate amount, so that the magnetism was proportional to the current. Now the moving force is proportional to the magnetism, and it is also proportional to the current which is flowing through the mercury, and since the magnetism is also proportional to the current it follows that the moving force varies as the square of the current, and the fluid friction varies approximately as the square of the velocity. Consequently, the condition which I alluded to a short time ago is here fulfilled, and we ought to expect that the velocity would be proportional to the quantity of current passing. Of course the law I have spoken of is only true as a sort of approximation. The friction of the indicating mechanism is not proportional to the square of the velocity, and consequently that affects the result. The number of rotations made by the mercury is indicated by the rotation of a float of special construction, resting on the mercury, connected by a spindle, with a train of wheelwork which indicates the total number of revolutions. The meter has also been adapted for observing alternating currents, and is rendered more delicate by having an additional shunt winding of very high resistance. This shunt is put in multiple arc with the lamps on the two mains of the house supply. The friction of the wheel train is reduced to a minimum by employing the finest and lightest mechanism which can possibly be constructed. I am sorry to say that Mr. Ferranti has not been able to furnish me with any tests or specimens of his new alternating-current meter, as he is even now introducing some more improvements. I am told the range is about 50-fold, and that it is very accurate. I may mention, in praise of Mr. Ferranti's ingenuity, that both Mr. Edison and Mr. Weston, in America, two of the most prolific inventors, tried to work out a similar instrument, and found it ineffective. They both described to me their attempts at this, and were quite astonished on hearing of the success which had attended Mr. Ferranti's efforts in this direction (applause). The chief difficulty which these experimenters met with was one which, until Mr. Ferranti attacked the problem, has been taken as a universal fact, viz., that mercury is unsuited for a permanent contact. They found that the mercury got covered with a film or powder which interfered with its free movement. I am informed that in Mr. Ferranti's instrument, where enormous care is taken to purify the mercury, there is no such action at all.

(To be continued.)

THE PHYSICAL SOCIETY.

At the last meeting of the Physical Society, held on January 26th, Prof. S. P. THOMPSON read a Note on

"A Relation between Magnetisation and Speed in the Dynamo Machine."

In a Note on "The Conditions of Self-Excitation in a Dynamo Machine," communicated to the Society May 12th, 1888 (see *The Electrician*, May 18, 1888, p. 43), the author arrived at the conclusion that in a well-built dynamo, where C is the number of conductors counted round the periphery of the armature, n the number of revolutions of the armature per second, N the whole number of magnetic lines (in C.-G.-S. units) which traverse the armature, i the current in the circuit, S the number of convolutions in series with the main circuit, ΣR the sum of the electric resistances (in C.-G.-S. units) of the circuit in which the E.M.F. operates, and $\Sigma \rho$ the sum of the magnetic resistances in the magnetic circuit, the equation of E.M.F. is

$$n C N = \Sigma R i,$$

and the equation of magneto-motive force is

$$4 \pi S i = \Sigma \rho N,$$

from which by multiplication together

$$4 \pi S n C = \Sigma \rho \Sigma R,$$

or the product of the magnetic and electric resistance is constant for a definite speed of rotation. He now desired to call attention to the fact that the last equation gave the means of determining the limit of self-excitation when the speed was altered by a definite amount, for the equation may be written

$$\frac{4 \pi C S}{\Sigma R} = \frac{\Sigma \rho}{n},$$

showing that self-excitation will continue until resistance to magnetism is proportional to the speed.

Prof. E. F. HERROUN then read a Paper on

"The Divergence of Electromotive Forces from Thermo-chemical Data."

The author pointed out that it had been remarked by many physicists, including Favre, Julius Thomsen, Braun, Helmholtz, Willard Gibbs, Wright and Thompson, and others, that the observed

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E.M.F.s of many voltaic cells do not agree with the values calculated from thermo-chemical data, and stated that the object of the investigation described in his Paper was to throw some further light on the subject.

Cells of the Grove or Bunsen type, in which nitric acid is reduced by the evolved hydrogen, were excluded on account of their non-reversibility and the complicated secondary actions which occur in them, and the investigation was confined to cells of the Daniell type.

It has frequently been assumed by physicists, and notably by Helmholtz in his Paper,* that the divergence between the observed and calculated values of the E.M.F. is to be explained, in the case of cells giving a deficiency of E.M.F., by a portion of the chemical energy appearing as heat in the cell, and in the case of cells giving an excess of E.M.F. by their partly working at the expense of the heat of surrounding bodies. The author objects to this explanation that the E.M.F. of a cell, such as the Latimer-Clark cell, which is in excess of its calculated value, ought to increase with increase of temperature, which, however, is not the case. The author describes a long series of experiments made with the following pairs of metals in contact with their own salts :—

Cadmium and copper.	Lead and zinc.
Mercury and copper.	Cadmium and iron.
Silver and copper.	Tin and copper.

The range of the experiments was greatly limited by the fact that very few cells could be found which even approximately fulfilled the conditions required, viz. :—Tolerable freedom from polarisation, perfect reversibility, low and constant internal resistance. The author finally arrives at the following conclusions :—

1. The primary factor in determining the electromotive force of a voltaic cell is the relative heat of formation of the anhydrous salts of the two metals employed.

2. That this E.M.F. may set up chemical changes of a different direction and character from those predicable from the heat of formation of the dissolved salts.

3. That the E.M.F. set up by (1) may be, and usually is, supplemented by the energy, or a portion of the energy, due to the hydration or solution of the solid salts, and may have values which accord with the heat of formation of the dissolved salts.

4. That in those cases in which there is no chemical attraction, or a very feeble attraction between the water and the salt, the negative heat of solution is derived from sensible heat, and is not supplied by the free energy of the chemical change. All cells in which such salts are employed opposed to zinc should have negative "thermo-voltaic constants," and evolve heat when they send a current forwards.

5. That when metals whose salts have purely negative heats of solution are opposed to metals whose salts they can replace the E.M.F. set up is *in excess* of the total thermal change. Such cells, therefore, absorb sensible heat when worked forwards.

6. That taking the foregoing facts into consideration no cell exists which can furnish an E.M.F. in excess of the free energy of the chemical change ; *i.e.*, which can convert sensible heat into electric energy, when working at uniform temperature.

7. That certain metals have a tendency to form films of sub-salts on their surfaces, the formation of which, giving rise as it does to a different thermo-chemical reaction, naturally furnishes an E.M.F. which does not correspond with the values calculated from the heats of formation of their *normal* salts.

8. That the electromotive force of a voltaic cell furnishes a more accurate measurement of the "free energy," and therefore of true chemical affinity, than data derived from calorimetric observations.

LEGAL INTELLIGENCE.

In re Gaulard and Gibbs' Patent.

COURT OF APPEAL.—MONDAY, JANUARY 21.

Sir HORACE DAVEY, in opening the case for the respondent, said that he was yet at a loss to understand what the other side were prepared to say was the invention they supported. The nature of the invention as described in the provisional specification was one thing, as described in the amended and complete specification it was another, as described by Mr. Aston it was a third, and the invention as described by their witnesses was another thing still. In the course of Mr. Aston's long argument he had not heard one single attempt to grapple with the difficulty which was admitted by Dr. Hopkinson, Prof. Adams and Prof. Forbes in their evidence, namely, that the patentees had not attempted to set forth in their specification what were the essential features which they claimed as a speciality of their secondary generators. It was put in the forefront of the cross-examination, and both Prof. Forbes and Dr. Hopkinson admitted that they were unable to say that the patentee had stated in the specification what he considered essential to the working of his system, or what were the specialities upon which he relied. He (the learned counsel) proposed to show, first, that there were non-conformities between the amended specification and the provisional specification. The invention which was described in the latter was a wholly different thing from that described and claimed in the complete specification, and that the complete specification was wider than the provisional, inasmuch as it was less special. His second point was insufficiency of specification. By that he meant, not that a workman or an electrician could not construct the system from the description given, but that the patentee had not stated what was new and what was old, or what, perhaps, was of more importance, what was essential and what non-essential—that he had put in a wide, general claim, without sufficiently ascertaining (to use the words of the Statute) what his invention was. His third point was that the system of distribution which was claimed, and which the claim was intended to cover, was not novel at the date of the patent. He relied principally upon the publications of Jablockhoff (as expounded in Du Moncel's *exposé*), Edwards and Normandy, De Meritens (under the name of Johnson), and Marcel Deprez (under the name of Imray and Harrison). Having regard to the state of knowledge as disclosed in these publications, there was no room for a patent containing the wide general scheme contained in the present patent. Of course there was ample room for an invention to improve on any details, but there was no room for an invention such as that which was claimed of the whole system as a principle. He was unable, and (which was much more important) Sir William Thomson was unable, to see the slightest distinction between the so-called invention claimed here and that which was described in the prior publication of Edwards and Normandy.

To deal with the first point, that of nonconformity, the nature of the invention described in the provisional specification was this : A system of distribution by which an unlimited number of lights might be produced without any loss of energy in the primary wire, and that the patentee thought he had attained by means of a special construction of secondary generators or induction coils. If that had been aptly described, and if the invention had been successful, it would have been of marvellous value and power. The invention was not a general system of lighting by means of sending a current through a primary wire, which by induction coils could be utilised for lighting lamps or for motive power, but it was a system by which they could do that without any loss of energy in the primary wire. In a vernacular form the nature of the invention was this—that it enabled you to eat your cake and still have it. The principle which was the basis of this system was stated by the patentee as follows :—"When an electric current approaches or recedes from a circuit of solenoidal form, it determines in this latter a current of induction without in any way qualifying the value of the primary current." The obvious and real meaning of those words was that the current of induction was determined in the induced circuit, the secondary circuit, without the value of the primary being in any way modified—in other words, that there was no loss of energy in the primary wire when a current of electricity was induced in the secondary coil. If that were true it would amount to something like perpetual motion. The witnesses for the other side said it was not true, but that it might mean "without the operator modifying the current." The witnesses had to give a strained, unnatural, and forced construction to almost every word of the provisional section in order to make it sense. The patentee's idea seemed to have been that because there was no communication between the primary wire and the secondary wire, therefore the current suffered no loss of energy, no modification, in the primary wire, in consequence of a current being induced by means of induction coils, and therefore the number of lamps which might be lit was unlimited. If there was a loss of energy at every installation or station, the number would be limited when your energy was exhausted, but if there was no loss of energy in the primary wire, they might have as many installations on as the primary wire was long enough to bear. The patentee claimed to achieve this end by the special construction of his secondary generator or induction coil. When a patentee stated in the provisional specification the principle involved in his system, he was not at liberty in his complete specification to give the go-by to that and claim a general principle of which he had given a particular example in his provisional specification. Mr. Aston had said over and over again that the essence of this invention was the use of high tension in the primary current and low tension in the secondary current. From beginning to end of the provisional specification there was nothing whatever about the tension in the primary or secondary current. There was not one word as to the ratio, or proportion, or relative strength of tension in the wires, and it was not stated that, as part of the invention, the primary wire was to have high tension. Coming to the amended complete specification, he submitted that it abandoned the special characteristics of the invention as described in the original, and claimed the general principle of a combination of alternating currents of high tension with secondary generators for the purpose of producing light and power. There was omitted from the amended specification that which the patentee in the provisional specification had stated to be the principle which was the basis of his system of distribution. Not a word of the following was in the original : —"We take an alternating-current dynamo machine, constructed in such a manner that the resistance of the inductive system is greater than that of the external circuit uniting its two extremities ; but we do not use or desire to use the alternating-dynamo machines that produce currents other than the currents of high tension." He submitted that a man could not take up a patent for a dynamo of high tension unless it was a particular construction of dynamo which produced high tension. There was not a word in the amended specification as to the secondary current being of lower tension, nor was it stated how many windings of the secondary coil there should be on the induction coil; on the contrary, it was stated that the apparatus con-

* "Ueber die Thermodynamik Chemischer Vorginge." "Sitzungsberichte der Akademie der Wissenschaften zu Berlin." 1882. Translated in 'Physical Memoirs" (published by the Physical Society, Vol. I., part 1.)

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stituting the induction coil might be arranged either for the purpose of increasing the tension or for increasing the quantity according to the demands of the consumer. "To sum up, we claim, in accordance with the law, the privilege of exclusively working our process of distribution characterised by the following points, above explained—the employment of an alternating current of high tension"—not an alternating current produced in any mode, but "an alternating current of high tension"—"for the generation on a number of secondary generators of induced currents individually utilised either for the production of light or motive power." His learned friends had talked about the Gaulard and Gibbs system, but when he came to examine what they meant, it was not one single one of the special heads mentioned in the specification, it was merely this general combination of an alternating current of high tension with secondary generators of any construction used for the production of light and motive power. They were right. The claim in the patent was for the combination of an alternating current of high tension, however produced, with secondary generators, of whatever construction, for the production of light and power by means of the induced current. The marvellous power of producing light or motive power at an unlimited number of stations without any loss of energy in the primary wire was altogether omitted in the amended specification, but, according to his contention, that was the speciality of the provisional specification. The invention was enlarged by being made less special, because it was made to include not only a system of distribution which (if true) had that great economical value, but *all* combinations of alternating currents of high tension with secondary generators for the production of light and motive power. A man was bound to state the nature of his invention in the provisional specification; in the final he might specialise it, but he could not drop one of the essential constituent elements in the combination in the provisional. This was the first case he had seen in which the whole of the provisional was taken up in stating the principle which was the basis of the invention; and in which the patentee, when he came to the complete specification, threw that overboard in the most marked manner by striking it out on amendment. He submitted, therefore, that the patent was bad for nonconformity of the final specification with the provisional.

With regard to the second point—of insufficiency of specification—what was the invention claimed? It was a perfectly general claim, as was shown, he contended, by the evidence of Dr. Hopkinson, Mr. Swinburne, and Prof. Adams. Putting the system into practical effect, it might be admitted at once that one of its merits was that it gave a means by which wires of low tension could be used in houses where they wanted low-tension currents. But that was not the question; the question was, what the patentee had described and claimed. Assuming the invention to be, as Dr. Hopkinson described it, for a special class of secondary generator or induction coil, had the inventor stated what was or was not essential, what was or was not the particular specialty in his secondary generator which he wished to employ? They attached so much importance to this that it was put in the very forefront of Dr. Hopkinson's cross-examination. That gentleman said there was nothing in the specification to show which things were and which were not essential to success. Prof. Forbes said the patentee did not point out any essential features. Assuming a secondary generator or induction coil of a particular type or class to be claimed, on the showing of both those gentlemen the class or type could only be ascertained by the two examples given by the patentee, and there was nothing in the specification which told one which features or characteristics or elements of the two descriptions were considered to be essential or non-essential. He had not warned the public off, and told them what they were to use and what not, nor had he told the workman what were the essential features, and he did not inform the world (as he was bound to do) what the essential element was; in fact, the specification wholly failed to inform those who desired to put it in force what they might do and what they might not do in order to produce the desired result. Mr. Aston, he thought, was ultimately inclined to say that it was a combination of an alternating current of high tension with a secondary generator with a divided core. Had the patentee said that a divided core was necessary? A workman would make it with a divided core; but why? Not because he was told so on the face of the patent, but because every practical core at that time in the market or known to makers had a divided core. Dr. Hopkinson had said that every practical induction coil at that date, in 1882, had a divided wire; so there was no speciality whatever in it. With one exception, all the anticipations were described and used as divided cores. It had been said that Jablochkoff did not describe a divided core; but in Du Moncel's *exposé*, which was as good a publication as the patent itself, it was undoubtedly a divided core. Sir William Thomson said that any ordinary induction coil known at the time would work as well as those described in the specification—in other words, there was no speciality; and in reply to another question he said the induction coil described by Gaulard and Gibbs was not the best form known for the purpose, but so far as it deviated from the ordinary form it was not an improvement, but the reverse. They had been told that the Gaulard and Gibbs system had been applied in a hundred towns in America, at the Edgware-road and at the Grosvenor Gallery. In every one of those cases, according to undisputed evidence, the secondary generators were not of the construction mentioned in the patent, so far as the description in the specification differed from an ordinary induction coil.

In regard to his third point—that of anticipation—he said boldly and fearlessly that Edwards and Normandy, in every singular particular which was claimed in the amended section, was an anticipation of the Gaulard and Gibbs patent. It might be extraordinary that Sir William Thomson at the time he gave his lecture in York was not aware of the prior publication of Edwards and Normandy, but that did not alter the fact. Sir William Thomson was not a patent agent, and he had a great deal of other work to do besides reading patents. He was bound to say that Sir William Thomson did not think so highly of Gaulard and Gibbs, or of Edwards and Normandy, as some other people did. Gaulard and Gibbs were claiming a monopoly of the principle of transformers, but if that principle had been previously disclosed they could not patent it. For what did they claim a monopoly? Not for an invention, but for its exploitation, because rich men had commercially developed a system which had been previously described by humbler men, but men of great distinction, in advance of their time. It was preposterous. Let them have all the merit which attached to those who see the value of an idea and carry it into practical commercial success, but they cannot therefore claim to be monopolists of the idea or the principle itself. He defied anybody to draw any distinction between the system described by Edwards and Normandy, and that described by Gaulard and Gibbs. The patent was bad for want of novelty. Dr. Hopkinson had utterly failed to distinguish Jablochoff's system from the plaintiffs', and if he (the learned counsel) had not been told the contrary, he should have thought that Gaulard and Gibbs must have had Edwards and Normandy's specification before them—even in its errors the latter had anticipated Gaulard and Gibbs. Absolutely no sound distinction could be found; in Sir William Thomson's words, Edwards and Normandy required no modification whatever—it was exactly, even in its mistakes, Gaulard and Gibbs's system. There were the alternating current, the secondary generator, the divided core, and (on the testimony of Dr. Hopkinson) passage from high to low tension in the description of Edwards and Normandy. What was there in the plaintiffs' specification which was fuller than that in any of its details? The only distinction that Dr. Hopkinson could draw was that Edwards and Normandy did not get their current from an alternating machine. They could not get a patent for a particular instance of what had been aptly and sufficiently described in general terms. They might get a patent for an improvement, and they might be entitled to a monopoly of that improvement, but they could not get a patent for telling the world, or telling the previous patentee, the best mode of using his patented machine. Then with regard to De Meritens, with the exception of the faulty form of induction coil, Dr. Hopkinson could not point out any distinction between it and Gaulard and Gibbs. Except for the source of the alternating current there was nothing in Deprez which differed from the plaintiffs' combination. If Deprez had come after Gaulard and Gibbs, would anybody suggest that he could have defended himself from an action for infringement because he did not get his high-tension alternating current from a dynamo? In conclusion, he contended that after the disclosures in the instances he had cited, there was no room for any one to take out a patent for the principle of a combination of alternating currents with secondary generators as a means of lighting or of giving motive power by induced currents. Let Gaulard and Gibbs have the full benefit of their enterprise, but do not let them seek to arrogate to themselves a monopoly of something which they did not invent, of something which was as old as the year 1877-78, and which had been fully and adequately described in Edwards and Normandy.

At the close of the learned counsel's address the Court adjourned.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 19th*, 1889.

Looking back over the past year, perhaps the feature which most arrests attention in the industrial department of electricity has been the utilisation of electric power both in manufactures and in street railway work. The demand for electric motors is now greater than it has ever been before, and there is every reason to believe that 1889 will witness a tremendous extension of their use. As an adjunct to central stations of all sizes stationary motors are now looked upon as indispensable, and nearly all the large companies in the leading cities have their regular rates for motor service just as they have for arc and incandescent lamps. Owing to the greater number of arc circuits there has perhaps been more opportunity of introducing constant-current motors, and a very large number of these are now running in New York, Boston, Philadelphia, Chicago, Baltimore, San Francisco, Detroit, and other cities; but the incandescent central stations have also been called upon to do a large proportion of the work, especially in New York and Boston, where the sale of power is understood to have added materially to the income of the local Edison Companies. Up to the present time no very great stride has been made in the establishment of power stations, pure and simple, but there is promise of some interesting work of this nature. For instance, in this city where independent power stations on the Daft and Sprague system are already operating, the "C. and C." Motor Company propose to try an important experiment. In other words, they are about establishing a new factory for the manufacture of their well-known motors, of which about 500 are in use in this city alone, and probably some 5,000 all over the country, and in connection with their factory they will equip a building for miscellaneous manufacturing purposes with electric power,

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no other provision for power being made. Small motors will be put in on each floor, operated from the generating plant in the basement, and these motors will be put just where the convenience of the customer on any floor may demand. In addition to this, the company will run out wires through the immediate vicinity, and there furnish power to anybody who may want it. The building which the company have secured for this purpose is a fine one, and as the matter is in capable hands I look for a very successful outcome of this experiment, which will go far, I think, to show how far much better electric power is than any other for the wants of small manufacturers.

Turning to electric railways, the development has been, if anything, more remarkable than that which may be noticed in the stationary motor department. Just about a year ago, there were about a score of roads operating in this country, and about as many more were projected. None of these roads were of any very great magnitude or importance, and many of them were operated with motors and cars that might well be described as relics of a barbaric age in the art. The twelve months have seen a wonderful revolution. The number of roads running has increased from a score to over 50, and at the present time the number of roads actually building, contracted for, or for which companies are formed, is over 75, so that should they all go into operation this year, as may be confidently expected, we shall have, at the end of 1889, no fewer than 125 electric railroads operating in this country. Many of these roads will be of considerable magnitude; several of them have already a length of from 10 to 14 miles, and the equipment often consists of 15, 20, or 30 cars. There has been a great improvement from time to time in the quality of the work. The motors have become better fitted to the demands made upon them, line construction has been greatly improved, and the whole business may be said to have taken a respectable shape. A year ago it seemed hard to convince street railway men that electricity was more than an experiment, and that it was worth while to put in a reasonable sum of money for the solid construction of an electric equipment. The consequence was that the work was but too often done in a slipshod, cheap and unsatisfactory way. But now, as instanced by the roads in Washington, Cleveland, and Boston, as well as other places, the construction is of a very substantial character, and even goes so far as to be ornamental. General satisfaction seems to be felt by the public where these roads have been installed, with their light and tasteful appliances, as compared with the gloomy and clumsy looking elevated roads with which we are afflicted in New York. In connection with the elevated roads it will be remembered that Mr. Daft has been giving successful demonstrations on the Ninth Avenue road, and it is expected that some definite step will be taken this year by the management as a result. It is further to be borne in mind that the Julien Electric Company have done some very good work in the exploitation of the storage system, and they certainly have won the goodwill of the public by the manner in which they have shown that luxurious street car travel can be put within the reach of everybody. Storage car work is also going on in St. Louis and Sacremento and other places; but the rush in this particular section of the field has not been quite so great as was expected. Nearly all the roads of which I have spoken are operated on the overhead system, but the Bentley-Knight conduit system has been given a trial in connection with the new work of the west-end railway in Boston, and it has just been laid down in Fulton-street in this city, the construction of the conduit being likely to be finished in a day or two. Owing to the unusual mildness and openness of the winter, electric railway construction work had, in fact, been continued much further through the cold months than was anticipated, and in the Pacific and Southern States, where frost has not to be combated with, the work is going on very actively without any intermission. With regard to the roads in the north, it was feared that perhaps they would make a bad show when subjected to the strain of wind and snow, but wherever the opportunity has arrived they have stood up nobly. At St. Joseph, Mo., a few weeks ago, during a terrific storm, when every other electric service in the city was suspended, the electric roads went on with their business in the most matter-of-fact and re-assuring way, and reports of a similar nature now come from Davenport, Ia., where, during a typical blizzard, the Sprague road kept on running in spite of the gale, and through snow averaging from 6in. to a foot.

It might be surmised that all this work naturally creates a demand for men to carry out the contracts. This is the case, and it very often happens that the work has be done by men who are entirely new to the business. That they can do it all speaks volumes for the advances that have been made in simplifying and systematising the apparatus and appliances. In running electric cars, men are taken direct from the horse cars, or else are practically picked up out of the street and put at once to work, with very little instruction. In the matter of line construction and central station equipment perhaps more care and experience are required, but here, again, very fair success has been obtained with the labour employed. An interesting evidence of the extension of electric industries was afforded recently in Chicago, where it was necessary to wire up the Opera House for some 400 lights in less than a week. To carry out the contract it was necessary to employ some fifty or sixty workmen, and owing to the activity in electric matters generally, it was not easy to obtain such a number. Still, they were recruited, and the work was satisfactorily performed and completed in less than three days. This little incident may be regarded as showing how rapid has been the development of the industry, for I do not believe that it would have been possible two years ago, or even a year ago, to get that amount of work done in such a hurry. Of course there is plenty of room for improvement in the quality of the work, but highly praiseworthy efforts are being made in that direction, such as those, for instance, of the New England Electric Exchange, and the standard of the requirements in performance is being steadily raised.

Another feature in this connection worthy of mention has been the establishment of a number of firms of electrical engineers who stand ready to undertake the designing, construction, and equipment of plants for electric light and power. While a great many companies, perhaps all, find it advantageous to do their own work of this character, it is very often convenient to be able to turn it over to some firm, the members of which have a reputation and of whose ability to carry out the contract there is no doubt. These firms are now to be found in all parts of the country, often serving as special agents of the various systems, and in many other cases standing ready for all the work that may come along, no matter what may be the system. The development of electric lighting has called into existence this class of practical experts, and in one way and another they are rapidly becoming a mainstay of the business as the men to whom we must look for good advice to local parties intending to put in electrical apparatus, and for good work when the choice has been made. The more recent development of electric railroad work has created another field in which electric engineering can display its abilities, and hence the number of such firms bids fair to increase.

One of the largest gatherings that has attended the meetings of the American Institute of Electrical Engineers was present on the evening of Jan. 8 to hear a Paper read by Mr. E. G. Acheson, of Pittsburgh, entitled "Lightning Arresters and the Photographic Study of Self-Induction." The Paper, which was of considerable length, was based primarily upon experiments which had been made for the protection of lead-covered underground cables from lightning discharges, experience having shown that the insulation became punctured in a most unaccountable way. To these were later added experiments which were made in the light of the results obtained by Dr. Lodge on static discharges and his now celebrated "alternative path." Mr. Acheson first described a number of experiments similar to those made by Dr. Lodge and others, which he varied to conform to the conditions to be found in underground cables. In general, his results may be said to correspond fairly well with those of Dr. Lodge as regards the relative size of the "A" and "B" spark, and with the use of iron and copper in the alternative path; but Mr. Acheson differed entirely from Dr. Lodge in the explanation of the results obtained and in the nature of the "B" spark. Generally stated, Mr. Acheson holds that the wire shunt at the "B" terminals is not an alternative

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path in the sense that Dr. Lodge assumes. The latter's argument is that the self-induction in the wire creates such a high self-induction as to offer such a virtual resistance that the spark prefers to jump across the air rather than pass through the wire. In other words, the wire is put into a temporary state of enormous resistance, pure and simple. Mr. Acheson's theory however, differs from this in that he asserts that the "B" spark is not produced direct from the discharge of the jar, but that it is a secondary spark induced by the self-induction of the wire shunting the "B" terminals; in other words the spark "B," according to Mr. Acheson, has an independent origin from that of "A." In order to strengthen his position in this theory, Mr. Acheson has had recourse to photography, by means of an apparatus consisting of a perforated revolving screen, with which he obtained images of both "A" and "B" under varying conditions. The theory which he has assumed Mr. Acheson considers confirmed by the fact that while the "A" spark is shown by photography to be instantaneous in all cases, leaving a clearly defined image of the aperture on the sensitive plate, the "B" spark, on the contrary, under the conditions is found to have a ghost like tail following it, which would seem to show that the "B" spark is prolonged, and that there is a time interval between the spark "A" and the end of spark "B," due to the time required for the production of the self-induced current in the wire shunting the "B" terminals. Mr. Acheson further strengthens his theory by a number of other considerations which would lead me too far; but the results he obtained are certainly worthy of consideration by all interested in this subject. The paper is full of suggestions, and barely touches the subject, so that we shall no doubt hear more in the future.

CORRESPONDENCE.

THE PHYSIOLOGICAL EFFECTS OF ALTERNATING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter of your correspondent "Telegraphist" and recent American notices prompt me to call attention to the fact that the resistance of the human body to alternating currents is only about *half* what it is to continuous currents. (See *The Electrician*, April 30, 1886, p. 503.)

This curious fact was first pointed out by Dr. W. H. Stone in his Lumleian lectures before the Royal College of Physicians in April, 1886, and has been confirmed by others since.

In practice here I have many times proved it, and have also frequently found that patients (and healthy visitors also) who can bear, say, 20 or more milliamperes of continuous current without pain, are utterly unable to bear 1 milliampere of the alternating current of the secondary circuit of an induction coil.—Yours, &c.,

H. NEWMAN LAURENCE.

The Institute of Medical Electricity (Limited),
January 29, 1889.

TELEGRAPHY WITHOUT WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your editorial comments on my letter on the above subject in your last issue, I should like just to point out that whereas Mr. Preece, in the account of his own experiments which he read before the British Association at Manchester, said:—"The disturbances due to the mixed working currents on our telegraphs cannot be appreciable beyond 450 feet," in the experiments described by myself this intervening distance was increased to very nearly double this amount without the inductional disturbance becoming at all very faint, and this with a secondary wire only 110 yards in length.

Considering that the law of inverse squares applies, the above is, I think, worth calling attention to.—Yours, &c.,

A. A. CAMPBELL SWINTON.

66, Victoria-street, S.W., January 29, 1889.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. A. A. Campbell Swinton having invited me to hear the induction effects described in your last issue in Queen Victoria-street, which I had suggested were due to the proximity of one of our type-printing telegraph wires, I found that they were undoubtedly due to a Wheatstone automatic instrument. But from previous experience of the effect of induction upon our City telephone wires, I am convinced that such powerful induced discharges could not be elicited from conductors 300ft. apart under any circumstances; but I beg to submit the following explanation of the phenomena:—The soil in the locality is dry gravel and sand. The earth connections are imperfect. The Post Office pipe being somewhat in the route of the earth, portion of the circuit between the two stations forms part of a derived circuit, consisting of gas, water and other pipes, and the ground itself. Throughout its length this pipe is subject to the influence of the Wheatstone alternations, which become perceptible in any part of the pipe which is insulated or partially insulated and unfurnished with a discharge path.

I am the more inclined to attribute the effects observed to this source, and not to direct inductive action, from the fact that our wire, which is parallel to both, and conveying alternate currents of greater strength than the Post Office wires, has so little effect upon the telephone wire that it requires some knowledge of the signals to detect the induction at all; and, on the other hand, the induction of the Wheatstone working is altogether unheard in our wire.

In a case of direct induction through 300 feet our wire should share with the telephone wire.

Another telephone wire which appears to run at right angles to the Post Office wire shows the same effects as Mr. Swinton's wire, both using the same earth.

I am aware that electrostatic inductive effects are visible in vacuum tubes at great distances from an electrical machine, being well visible at 30ft. from a 2in. spark machine, but the action is progressive, commencing after the passage of sparks, and continuing for some time after the last discharge. But electrostatic induction of this character is very irregular in its action, dynamically feeble, and will not produce signals sharp and clear like those obtained in the telephone wire.—Yours, &c.,

17 and 18, Cornhill, London, E.C., F. HIGGINS.
January 28, 1889.

ALKALINE ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the inquiry of Mr. A. E. Greville in your last week's issue, I beg to say that, although local action in the gradual re-dissolution of the zinc no doubt takes place, it is so slow that it may be disregarded for ordinary periods.

In the case of the miners' lamp, there would not be a loss of 5 per cent. between the quantity of current put in and that taken out in twenty-four hours—a better result than any lead cell I have tried.

I am glad to hear of the experience of Mr. H. J. Coates, and beg to assure him that he need not fear any such accusation as he suggests.

Mr. Commelin and his assistants tried many positive plates of the kind described by Mr. Coates—probably with similar success—before they hit upon the present form which proved so surprisingly successful.—Yours, &c.,

P. BEDFORD ELWELL.

London, W.C., January 31, 1889.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As one who has been much interested in the development of secondary batteries, and as the inventor of the mechanical system of production of porous metallic electrodes by the compression of metallic particles into a coherent mass, (Patent 5,196 of 1881), I should like to be permitted to ask, with reference to the letter from Mr. Coates in your last impression, wherein lies the similarity which he claims for his battery with that of MM. Dezmazures and Commelin? He speaks of similarity and then proceeds to show that none

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exists. He used an amalgamated zinc plate. There is, as I understand it, no such thing in the Dezmazures battery, but instead an iron gauze, upon which zinc is deposited in the action of the battery. Mr. Coates says he used silver powder on a thin silver plate. This is distinctly a different thing from a plate formed by compressing silver powder into a coherent but porous silver plate, and the difference is as great as that between Faure's lead plate coated with powdered (red) lead, and the plates subsequently made of similar materials compressed into a coherent mass without any lead-supporting plate. If there is any real similarity between the battery referred to by Mr. Coates and that of M. Dezmazures, the former appears rather to have explained it away than to have disclosed it.—Yours, &c.,

London, January 28, 1889. W. Worby Beaumont.

THE AURORA BOREALIS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have been much interested in Mr. Norman Lockyer's new theory of the aurora, to which you refer in the leading article in your last issue. You there remark that it has not yet been shown in what way the theory of the meteoric origin of the aurora accounts for the geographical distribution of the phenomenon. It occurs to me, however, to suggest that, owing to the known presence of iron in meteorites, it is quite reasonable to expect that they would be deflected towards the magnetic poles of the earth. As bearing on this suggestion, it would be well to inquire whether the coronal arc is centred over the magnetic or over the geographical pole, a question on which I have not noticed any statement.—Yours, &c., W. M. Mordey.

London, Jan. 24, 1889.

[Our correspondent's ingenious suggestion receives support from the fact that the coronal arc is undoubtedly centred over the magnetic and not over the geographical pole. This fact is explicitly stated by more than one writer who has witnessed the phenomenon from high latitudes.—Ed. *E.*]

CONSTANT CURRENT REGULATION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have read with no little surprise the remarks which have been made in the correspondence columns of your esteemed paper on "Mr. Edmunds' Method of Maintaining Constant Current," and I beg permission to say a few words on this subject. About two years ago I had occasion to run a series dynamo used for the supply of a number of series lamps and driven by a separate steam engine. The regulation of the dynamo not being quite satisfactory, I threw off the governor belt and let the engine itself do the regulation for constant current. As the engine was rather far from the boiler the regulation was only perfect within small limits, but quite sufficient for this special case. Mr. Atkinson, representing Messrs. Goolden and Trotter, was present at the time, and will, I think, remember the facts. You have yourself kindly published a report which I sent to you later on in *The Electrician*, May 6th, 1887, page 560.

At about the same time Mr. Edmunds wanted to sell to me Hochhausen dynamos, which he claimed offered the best means of obtaining constant current. I told him then that I preferred to drive each dynamo from a separate engine, and I explained to him at great length why an engine without a governor would automatically adjust its speed so as to maintain a constant current. This explanation was then perfectly new to Mr. Edmunds, according to his own statement to me.

Much better results than those mentioned in *The Electrician* in May, 1887, have been obtained by me later on. In one case a well built engine, which was quite close to the boiler, was driving a Brush dynamo for the supply of 18 arc lamps and 24 glow lamps of 6 volts each. When all the 18 arc lamps were switched out at once, the current only rose from 10 to 11½ amperes.

I shall not enlarge on this subject at present, as I have had in my desk for some time already a Paper on this matter and several others, the publication of which has been delayed by some additional new matter on which I am still engaged

I may add that, according to information which I have lately received, the credit of having first explained the theoretical principles on which this regulation for constant current is based is due to Marcel Deprez, and, furthermore, the method is already fully explained in the excellent book of Silvanus P. Thompson on "Dynamo Electric Machinery," 1st edition, page 100.—Yours, &c., Alexander Bernstein.

Hamburg, Mühlenkamp, January 28, 1889.

[We should like to point out that Mr. Edmunds, at the Institution of Electrical Engineers, expressly credited Mr. Bernstein with having been the first to employ the method; Mr. Edmunds, moreover, did not himself attach his name to the method, and perhaps we ought not to have allowed our correspondents to do so.—Ed. *E.*]

RED WIRE *VERSUS* BLACK.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In specifications for wiring it is frequently stipulated that red wire be used for the leads and black for the return.

Although there may be some slight advantage in this arrangement, we feel sure that no one would wish to insist upon its adoption at a sacrifice of efficiency.

We have invariably found, especially in damp situations, that the red wire shows a marked inferiority both in insulation and durability, and we shall be glad to hear whether this is confirmed by the experience of other electric light contractors.

We may add that this applies to wires of all manufactures that we have employed.—Yours, &c.,

Drake and Gorham.

ETHER RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Permit me to offer the following suggestion as a reason for gases or liquids of great mobility presenting little resistance to a moving body:—

Resistance to motion implies accumulation of heat energy in the moving body: and the converse, that a body would move free of resistance if the receptivity of the surrounding medium were such as to prevent any rise of temperature, is quite conceivable. This property of receptivity is dependent on molecular velocity and frequency of impact. A case at instance is that of hydrogen and other light gases of high molecular velocity, absorbing heat with greater rapidity than those of heavier molecular construction. If the molecular masses constituting ether are exceedingly small, they must, to have the same momentums or temperatures as ordinary gases, have exceedingly high velocities, and the relation between their velocities and that of the moving body should determine the efficiency of their receptive quality under those conditions. It must also be remembered that as ether permeates all known bodies it has great facility for impressing its influence on such.

If two such gases as hydrogen and oxygen be contained in vessels of equal volumes, under identical conditions of temperature and pressure, they will, according to the now generally accepted hypothesis, possess equal numbers of molecules, and the momentums of these molecules will be the same in each case; but oxygen has sixteen times the density of the hydrogen, hence its molecules must be of such a size as to ensure the same frequency of impact during any interval of time as the hydrogen. We have, then, the same amount of energy per unit of cubic content in each case, and we should expect the same resistance in each to the motion of any body. Oxygen, however, would give greater resistance to motion than hydrogen; but on a little consideration it will be seen that this is not due to its greater density (which, as shown, is not in gases a determining quality of resistance), but rather proportional to it, and this because the density of most gases is inversely proportional to their molecular velocities or receptivity. If, then, with ether we assume an abnormal degree of density, any calculation based on the assumption that its density is proportional to its heating or resisting property will necessarily be erroneous.—Yours, &c., N. G. Thompson.

7, Westminster-chambers, Victoria-street, S.W.

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ETHER, ELECTRICITY, AND PONDERABLE MATTER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Sir William Thomson's most interesting address he dwelt strongly on the probable existence of some ponderable matter in the ether of space. There must be some kind of structure in the ether, he said, its molecules must have some shape, and they must have some kind of relation to one another; but the difficulties in the way of forming a comprehensive theory are so great that as yet we cannot even imagine a finger-post pointing to a way that can lead us towards the explanation of electro-magnetic phenomena in space.

Might it be possible to erect such a finger-post as Sir W. Thomson believes may be imagined next year, or 10 or 100 years hence, by instituting a parallel between the imponderable, or almost imponderable, ether of the spheres and our better-understood ponderable atmosphere? Pure lifeless air—the unadulterated mixture of nitrogen and oxygen known to the chemist—is non-luminous; it is only when those invisible and impalpable microscopic organisms are contained in it which, within very recent times, have formed the subject of elaborate research by Pasteur, Schwann, Helmholtz and Tyndall, that a ray of light becomes visible during its passage through air.

Such organisms, or germs (which originate fermentation and putrefaction in nitrogenous substances), have been found to be so very slightly ponderable that they require several days to separate themselves from air and to sink to the bottom of an air-tight and quiescent glass vessel 2 feet square; and those who discern in the curiously misunderstood and somewhat discredited Mosaic account of Creation a finger post pointing to the comprehension of how this earth was first rendered habitable for man, explain the Scriptural statement that "in the beginning" the earth was in total darkness, by dwelling on the non-existence of organic matter upon its surface until by or concurrently with the first of the six acts of Creation [*motion* upon the face of the waters] such molecular "germs" were created as rendered the atmosphere penetrable to light from the sun.

Broadly stated, we regard electrical as well as magnetic phenomena as a succession of charges and discharges taking place throughout a series of polarised molecules of matter (liquid or solid), each molecule polarising the next, this the following one, and so on. May we not imagine the ether of space to contain a *something* bearing somewhat the same relation to it and to electricity that those invisible microscopic, or molecular, organisms bear to our atmosphere and to light?—Yours, &c, O. C. D. Ross.

15, Relf-road, East Dulwich, Jan. 19.

[We gravely question whether our correspondent's suggestion will be of much avail in the development of electro-magnetic theory.—ED. *E.*]

THE INSTITUTION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Surely the Council of the above Institution have committed a blunder by prohibiting the press reporting Papers, &c. I am afraid this must have a serious effect upon the membership. We in the provinces have always been heavily handicapped, and now we shall know nothing of the Institute's proceedings until months after. Surely the fact of our being debarred from the use of the library unless we visit it (a benefit which is also given to the general public) might have caused the Council to consider carefully before they applied the cloture to the press. We cannot deny there has been a vast amount of gratuitous advertising done at our meetings, but it is well known that the greatest sinners in this respect have at one time or other been members of the Council. Why should there be any difficulty in so arranging matters that our worthy Secretary should with a few strokes of the pen make short work of such advertisements?—Yours, &c.,

A PROVINCIAL MEMBER.

[Our correspondent may like to know that in all probability arrangements will shortly be made for furnishing the technical press with an "authorised abstract" of the discussions. In any case there has been no intention of suppressing the publication of the Papers themselves.—ED. *E.*]

PATENT RECORD.

APPLICATIONS FOR PATENTS.

18,825. A. C. COCKBURN. London. Improvements in switches for use in electric circuits. December 24, 1888.

18,832. E. T. BOSTON. Weston-super-Mare. An electric miners' safety hand lamp which may be used for domestic and other purposes. December 24, 1888.

18,854. H. W. SHORT. London. Improvements in electrical switches. December 24, 1888.

18,856. G. V. SHEFFIELD and M. LOWENSTEIN. London. Improvements in printing telegraphs. December 24, 1888.

18,858. F. J. BROUGHAM. London. Improvements in electro-chemical generators (La Société Perreur-Lloyd et Fils, France). December 24, 1888.

18,881. L. REULEAUX. London. Improvements in the preparation of materials which have to be submitted either to voltaic heat or to electric heating, combined with electrolysis. December 27, 1888.

18,900. M. W. DEWEY. London. Improvements in electric telegraphy. December 27, 1888.

18,908. G. B. GOODFELLOW and P. J. CHARLES. Manchester. Improvements in electric arc lamps. December 27, 1888.

18,911. B. H. ANTILL and E. F. H. H. LAUCKERT. London. An improvement in dynamo-electric machines. December 27, 1888.

18,922. S. WARDELL. Glasgow. Improvements in electrical switches. December 28, 1888.

18,930. J. BLAMIRES and W. BLAMIRES. Huddersfield. An electric automatic work detector and recorder. December 28, 1888.

18,966. J. TIMM. London. Improvements in or connected with telegraphic transmitters. December 28, 1888.

18,968. E. L. ZALINSKI and H. J. SMITH. London. Improvements in and relating to electric primers or igniters for blasting or firing mines, torpedoes, projectiles, guns, and the like. December 28, 1888.

18,978. T. W. BUSH. Broseley. An oblique-meshed grid-plate for storage batteries. December 29, 1888.

18,991. M. DOUBLEDAY (Nottingham) and T. W. BUSH (Broseley). A bent plate storage battery. December 29, 1888.

18,994. G. C. DYMOND. Liverpool. Improvements in and appertaining to the manufacture of metals or metallic alloys by means of electricity (J. M. A. G. Léscuyer, France). December 29, 1888.

19,034. W. J. S. BARBER-STARKEY. Manchester. Improvements in secondary voltaic batteries. December 31, 1888.

19,043. G. FOWLER. London. Improvements in and connected with insulating devices for supporting telegraph and other wires or electrical conductors. December 31, 1888.

19,047. R. W. HEWETT. Handsworth. A new or improved method of refining sugar by electricity. December 31, 1888.

19,049. F. V. ANDERSEN. London. Improvements in electrical firing keys. December 31, 1888.

19,058. J. Y. JOHNSON. London. Improvements in electric batteries (F. Gendron, France). December 31, 1888.

19,061. A. CORNWALL. London. An improvement in materials to be used in galvanic batteries. December 31, 1888.

19,070. C. WELLS. London. Improvements in electric arc lights. December 31, 1888.

COMPLETE SPECIFICATIONS ACCEPTED

January 2, 1889.

17,902. S. PITT. London. Improvements in apparatus for telephone exchanges. (C. E. Scribner, United States). December 29, 1887.

-56. J. Y. JOHNSON. London. Improvements in the manufacture of the incandescing portion or luminant of incandescent electric lamps. (T. Mace, United States). January 2, 1888.

531. H. EDMUNDS. London. Improvements in and means or apparatus for and connected with the generation, distribution, measurement, and control of electricity. January 12, 1888.

2,525. C. RICHARDSON. Manchester. Improvements in arc electric lamps. February 20, 1888.

2,586. R. KENNEDY. Glasgow. Improvements in and relating to incandescent electric lamps. February 21, 1888.

2,698. E. P. DOVE. Bradford. Improvements in the construction of sanitary and magnetic mattresses. February 23, 1888.

2,784. J. IMRAY. London. A method of and apparatus for electrically lighting railway and other carriages. (R. Imray, S. Australia). February 24, 1888.

2,785. E. F. H. H. LAUCKERT. London. Improvements in holders for electric glow lamps. February 24, 1888.

2,794. C. A. MCEVOY. London. Improvements in electrical firing keys or contact makers. February 24, 1888.

8,700. L. M. J. C. C. RENARD. London. Improvements in and relating to electric batteries. June 13, 1888.

16,556. H. C. NEWTON. London. Improvements in apparatus for adjusting the electric or other light in projecting lanterns. November 14, 1888.

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PATENTS SEALED.

December 28, 1888.

14,445. R. Haddan. London. Improvements in the insulation of submarine telegraphic cables and other electrical conductors. E. G. Prillwitz, Germany.) October 24, 1887.

14,461. A. Stetson. United States. Improvements in electric accumulators or secondary batteries. October 24, 1887.

14,729. W. H. Douglas. Stourbridge. An improved meter for measuring electrical currents. October 29, 1887.

14,831. W. R. Lake. London. Improvements relating to the regulation of steam-engines and other motors for working dynamo-electric machines or electric generators. (C. L. R. E. Menges, The Netherlands.) October 31, 1888.

15,118. W. Clarke and C. A. Parsons. Gateshead-on-Tyne. Improvements in electric incandescent lamps. November 5, 1887.

15,922. A. Coleman (Edgbaston) H. F. Jackson (Sydenham) and E. L. Dudley (Small Heath). An improved spring jack for telephonic and other electrical purposes in which it is desired to change or switch a current from one conductor to another. November 19, 1887.

16,217. F. C. Allsop. Bexley. Apparatus for automatically conveying and delivering letters and small parcels by electricity. November 25, 1887.

16,378. H. J. Allison. London. Improvements in or relating to switching feed and call appliances for autographic telegraph systems. The Writing Telegraphic Company (Incorporated), United States. November 29, 1887.

16,863. F. King. London. Improvements in or connected with means for the automatic electrical distribution and charge of secondary batteries. December 7, 1888.

12,455. J. Sherrin and J. V. Sherrin. Ramsgate. Improvements in the application of primary batteries and electro-motors to tricycles and other velocipedes. August 29, 1888.

12,986. R. Cresswell. London. An improved electric or galvanic sponge or pad for stimulating and curative purposes. September 8, 1888.

13,192. E. M. H. Andreoli. London. Improvements in or relating to bleaching by electrolysis. September 12, 1888.

January 1, 1889.

30. M. W. Dewey. London. Improvements relating to electric telegraphy.

46. W. S. de Lisle Roberts and J. S. Mollison. London. An improved atmospheric thermo-electric generator.

January 2, 1889.

85. A. Poleschko. London. Improvements in dynamo electric machines.

January 3, 1889.

112. J. Woods and H. W. Hatfield. London. A railway distant electric flashing signal.

118. W. P. Widdifield and A. H. Bowman. Manchester. Improvements in electric brakes for railway trains.

126. G. B. Luckhoff. London. An improvement in or relating to dynamos.

135. J. A. Timmis. London. Improvements in the arrangements for lighting and, or, braking railway vehicles electrically.

January 4, 1889.

179. C. Wells. London. Improvements in the use of incandescent lights.

189. W. H. Knight. London. Improvements in armature windings for dynamo-electric machines.

[Date applied for under Section 103 of the Patents, &c., Act, 1883, 6th June, 1888, being date of application in the United States.]

January 5, 1889.

238. J. D. Gibbs and E. Fresquet. London. Improvements in alternate-current dynamo-electric machines.

COMPANIES' MEETINGS & REPORTS

The Eastern Telegraph Company (Limited).

The thirty-third half-yearly general meeting of the Eastern Telegraph Company (Limited) was held on Thursday, January 24, 1889, at Winchester House, 50, Old Broad-street, London, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. George Draper) read the notice convening the meeting, and the minutes of the thirty-second half-yearly ordinary general meeting, held on July 19, 1888, and of the extraordinary general meeting, held on the 22nd November, 1888.

The CHAIRMAN having signed the minutes, and the report being taken as read, said: Gentlemen, I shall, as usual, give you some little details, more fully than you have in the report, though the report on the present occasion is very full indeed. Our revenue for the six months ended September, 1888, amounted to £310,104, as against £291,265 in the corresponding period of 1887, showing an increase of £18,839. The chief item of increase is from our holding of shares in the Eastern and South African Telegraph Company, the dividend on which is at the rate of 12 per cent., as against 8 per cent. last year, showing an increase of £7,800. The return for the half-year from our investment in the Black Sea Telegraph Company is increased by £1,393. Our Direct Spanish shares have yielded an additional £307. Interest gives us an extra £600; transfer fees £13; and our general traffic, chiefly South African and South American, £10,531, making a total of £20,644. But we have ceased to bring into our revenue accounts the dividend on Direct Spanish Company's debentures, which are now considered as an investment for our reserve fund; so we must deduct £1,805, leaving the total increase £18,939. The total working expenses for the half year amounted to £83,332, against £79,936, or an increase of £3,396. The details of increase and decrease are as follows:—General expenses in London £7,845, against £8,012, or a decrease of £167; working expenses at stations £59,962, against £56,386, an increase of £3,576. This is principally caused by the number of our foreign staff having been increased to work the triplicate cable from Porthcurnow to Malta and extension to Zante; also the duplexing of same. We have opened a new station at Cadiz, having put that place in telegraphic connection with Villa Real and Gibraltar. The laying of the new cable from Porthcurnow to Malta and Zante, besides giving us greater security and rapidity of working, has diverted to our system a large part of the Greek and Turkish traffic, which formerly went *viâ* the Continent. The foregoing explanations also account in a great measure for the increase in travelling expenses, rent, stationery, and maintenance of instruments. A greater number of messages have been carried this half year than in the corresponding period, and the work to be performed by our staff increases year by year. £1,000 of the total increase in the working expenses is explained by our having carried £5,000 to our reserve fund for the maintenance of ships, against £4,000 last half year. Repairs to cables amounted to £43,075 against £34,102, or an increase of £8,973. This is always an uncertain item in our accounts. Our ships have been busily employed in maintaining our system in a state of efficiency. The increase under this head is in the value of the new cable laid in, the total length being 130 miles, against 38 miles in the corresponding period of 1887. You will find on reference to the reserve fund that we have applied over £13,000 in reduction of capital expenditure, or, in other words, although we have spent over £13,000 in extending and improving our system, the capital expenditure remains at practically the same figure as last time. The Six per Cent. Debentures of the Direct Spanish Telegraph Company have been transferred to our reserve fund investments, which stand at £315,494, and our total reserves, after deductions, at £355,676. We pay the usual interim dividend at the rate of 5 per cent. per annum, and after providing for interest on Debentures, Debenture stock, and Preference shares, we are able to carry £36,616 forward to our next account, against £29,397, or £7,219 more than in the corresponding period of 1887. Now, gentlemen, I have given you these details because I think it desirable that you should follow as closely as possible the practical action of the Company. The statement I made in November last was so full of detail, so complete a history of the Company from the beginning, that it leaves me comparatively little to say to you to-day excepting this, that all that we put before you at the last meeting has been carried out. All the shares have been allotted and fully taken up; the work is in hand, and I believe by the time I have the pleasure of meeting you six months hence, if I have that pleasure, we shall have completed our West Coast of Africa cable; and that will not be completed one hour too soon. The enormous traffic going on just now to the Cape and the Transvaal, caused by the gold speculation, of course brings a great deal of grist to our mill. Any interruption to the present cable would be very disastrous, and would be felt to such a degree in London that I almost fear to contemplate what the outcry would be. When we have this cable completed we shall have two strings to our bow, and we shall thus meet, I fully believe, all the telegraphic requirements of the public. I may say that our system is working thoroughly well. We have a great deal of work to do to ensure that. I mentioned the very large sum we spent for repairs, but I think it is just worth while to give you some idea of the labour that is going on and the way our ships are employed. I think the information will be interesting to you. The work is so silently done that the public do not know anything about it. What we do shows that in our cable system we have a solid property. We are maintaining for the public benefit a grand system of cable communications, and it is done at considerable expense and a considerable amount of labour, our ships, I may say, being almost constantly employed on the work. As I said, the public do not know this, but we know very much about the details of the thing, and every day gives me more confidence in the working of our system. At the same time I am bound to tell you that cables, as well as men, get old, and we have to take care that we have all the older cables replaced by new ones; and we are trying to effect that out of income rather than by increasing the capital of the Company. The information I am now about to give you respecting the repairs applies to the last six months. On the 11th of August the Perim-Suakim cable was repaired; on the 9th of September the Aden-Bombay No. 1 cable was repaired; on the 19th September we repaired the Aden-Suez cable; on the 26th September the Perim-Suakim cable was again repaired, and again on the 10th of December. I think you may have observed in the papers that our ships, being in the neighbourhood of Suakim, gave every possible assistance to the British Government while the Egyptian and English troops were in action at that particular place. We have many times received thanks for the way we have acted in assisting them. We have taken away their wounded, and in great emergency have conveyed soldiers. I must say that our services have been thoroughly appreciated. I only hope, when we come to make a bargain with them, they will bear this in mind. The repairs I have already mentioned were done by one vessel. The repairs by another vessel were as follows:—On the 31st of August the Malta-Alexandra No. 1 cable; September 25, the Patras-Corinth cable; October 3, the Zanto-Corfu cable; October 9, the Rhodes-Sitia cable; November 19, the Chios-Tenedos cable; November 23, the Alexandria-Malta No. I cable; on November 27, the Suez-Suakim cable.

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Then there were the repairs by the "Electra" to the Aden-Bombay No. 2 cable, the Porthcurnow-Lisbon No. 1 cable, the Vigo-Lisbon cable, and the Vigo-Lisbon cable again. The "Amber" repaired the West African Company's Bolamo-Bissao cable (which we look after), the African Direct Company's Accra-Lagos section and the Lagos-Brass section, the Lipari-Milazzo cable, the Port Said-Alexandria cable, and the Thermia-Zea cable. During the six months we have had in all twenty-four repairs, and to effect those repairs our ships have had to steam 25,000 miles. That gives you some idea of the work that is going on every day; but at the same time, as you know, we have maintained our system in a thoroughly efficient working state, so far as the public are concerned. What I have stated, however, shows you the necessity of duplexing and duplicating the system. Had we not duplicated the system, and applied the duplex, we could not possibly have carried out the work we have done. I have frequently stated to you that above all things we desire to maintain the efficiency of our cables. We know that if we do that the public will get confidence in us, and then there can be no doubt of our having a growing and prosperous concern. The world cannot live now without the telegraph, and it is our duty, knowing the whole of the working as we do, to take care—without unduly increasing the capital, and while paying the shareholders a fair dividend—to maintain such a state of efficiency as will secure the confidence of the telegraphing public, and the confidence of the great body of our shareholders, which we value so very much. I now beg to move—

"That the report and accounts of the Directors to the 30th of September, 1888, submitted to this meeting, be, and the same are hereby, received and adopted."

The MARQUIS OF TWEEDDALE: I beg to second that.

The CHAIRMAN: If any gentleman is desirous of making any remark or putting any question, I shall be very happy to reply. Those in favour of the motion please hold up their hands. To the contrary. Carried unanimously.

Captain GOODSALL: Can you inform the shareholders how far from Aden or Bombay the No. 1 Bombay cable has gone?

The CHAIRMAN: I expected to have a report in to-day that the repairs had been effected. We expect every hour to hear that the cable is spliced.

Captain GOODSALL: What is the distance?

The CHAIRMAN: Seven hundred miles from Aden.

Captain GOODSALL: Has the cable been repaired there before?

The CHAIRMAN: Not at that particular place.

Captain GOODSALL: What is the condition of the cable?

The CHAIRMAN: You are an old servant of the Company?

Captain GOODSALL: I am.

The CHAIRMAN: You should know all these points as well as we do.

Captain GOODSALL: The shareholders may wish to know as well as I do.

The CHAIRMAN: The gentleman now addressing you was a captain in the Company's service. I may say that he left the service for the good of the service, and therefore I have nothing further to say. In putting his questions he has some object; but if he wants any actual information as a shareholder, he is perfectly entitled to it.

Captain GOODSALL: I am asking for information for my own use, and the use of the shareholders. I want them to know about the matter as well as I do. You have an account for advertising—kindly tell me where you advertise in London. I have only seen an advertisement in *The Electrician*, and if we pay £221 for that we are paying too much. Last half-year it was £540. It is not right for the Chairman of the Company and the Managing Director to have a share in a paper—that is, in the only paper that the Company has advertised in. Why not advertise in the *Electrical Review*? No, because your Chairman and Managing-Director advertise in a paper which is their own property. We ought not to advertise in this paper. Advertise in *The Times*, if necessary, where there are 50,000 or 60,000 copies a day. *The Electrician* has probably about 2,000 a week. Here is another thing, £1,034 for office expenses. I have looked over several companies' accounts and I find that many of them get on very well without office expenses. Here is another point. The "Mirror," £8,800 for working expenses. This is far too much from what I know of the work. From that I can gather that the Chairman was away with a number of friends cruising.

The CHAIRMAN: Hear, hear.

Captain GOODSALL: But you ought to pay that portion, and not charge the Company with it. That is the proper way. I leave this to the shareholders. They can hear what you say about me, that I am a discharged servant.

Dr. WALLER: I am glad to hear the gentleman conclude by saying he will leave these matters to the shareholders. In my judgment (and I have attended as many meetings as most men) I never saw anything so irregular, so disorderly as this gentleman's proceedings to-day. He has appealed to the shareholders. I do not hear one sympathetic voice in approval of the course which this discharged captain has taken to-day. I am very glad to hear by the acclamations that my view and not his is the view of this meeting. Sir John, I hope you will not condescend to any further explanation in the matter. We can all pretty well understand it. I shall therefore myself leave the matter, having risen—merely because there was an appeal to the shareholders—to express my feelings, which I am glad to see are the feelings of the shareholders present.

The CHAIRMAN: I would have treated—and I do treat—the remarks of the gentleman (Captain Goodsall) in the way they ought to be treated, but there are two points I must deal with. It does appear to the shareholders as if there was a charge against the Company. First of all, I would reply to what has been said in connection with *The Electrician*. I want gentlemen connected with our Company to know that *The Electrician* was established for the purpose of recording the best scientific opinions upon questions relating to telegraphy and electricity. Sir James Anderson, myself, and one or two other gentlemen interested in telegraphy, established that paper, but we have never taken a shilling profit out of it since it was established. We have established it mainly for the benefit of the great system with which we are so closely connected. It is an enormous benefit to our *employés* to be kept informed of the scientific progress of the business in which they are engaged. I think that is a sufficient answer. It is very important that telegraphic science should be disseminated among those in our service, so as to make our work more and more progressive and satisfactory. As to the other point - and I say this with all due deference—I do go about occasionally in the autumn and sometimes in the spring when there is any important negotiation going on. These negotiations I have found much more successful when carried out by interview than when conducted by correspondence. I can say with the greatest confidence—and I am a large shareholder—that the Company would not have occupied the position it does to-day but for our coming into frequent intercourse with the Great Powers of Europe. I have taken advantage of the ships occasionally when they have been moving about from place to place for the purpose of cable repairs, and I have taken friends with me—gentlemen of distinction whose opinion is of the greatest importance and value, and cannot fail to be of benefit to us. These occasional visits which some of the Directors, Sir James Anderson, and myself, have made from time to time, have added strength to our position; and we intend to continue them, as we believe they are in the interest of the Company. There is a very important business now pending—the renewal of concessions in a certain part of the world. It is no advantage to me—but rather the contrary to go; but I am going abroad in connection with the business because I think I shall do good in bringing about a renewal of these concessions on such terms as will be satisfactory and beneficial to the Company. I thank you for listening to these personal explanations. It is a pity that they should be required at all, but I have made them, and I hope they will be satisfactory. The motion has been seconded, and I now put it to the meeting. To the contrary. Carried unanimously.

Mr. BURNEY: Were the debentures offered at the extraordinary general meeting all taken up?

The CHAIRMAN: Yes, everything is placed. The next resolution is—

"That Lord Sackville A. Cecil, who now retires, be, and he is hereby re-elected a Director of the Company."

Sir JAMES ANDERSON: I beg to second that.

The CHAIRMAN put the motion in the usual manner, and declared it carried unanimously.

Lord SACKVILLE CECIL: Gentlemen, I am very much obliged to you for this renewal of your confidence in me.

The CHAIRMAN: The next resolution is—

"That Sir Albert J. Leppoc Cappel, who now retires, be, and he is hereby, re-elected a Director of the Company."

I think I should state to you who Sir Albert Cappel is. He has been at the head of the Telegraph Department in India for a considerable number of years. He is thoroughly acquainted with telegraphic work in India, and we thought it would be a very great advantage to have a gentleman of his experience on the Board. It keeps us in touch with the Indian Government, and my opinion and the opinion of the Directors is that it will prove a great benefit to the Company. We made this selection purely on the ground that Sir Albert Cappel was the best man we could find to fill the seat at the Board rendered vacant by the death of Lord Alfred Paget. I can only assure you, from my own observation and from the correspondence that passed between India and London while Sir Albert Cappel was at the head of the department there, that he is one of those men who have taken a deep and earnest interest in the progress of telegraphy.

Mr. G. G. NICOL: I have great pleasure in seconding the motion.

The CHAIRMAN put it in the usual way and declared it carried unanimously.

Sir A. J. L. CAPPEL: I am exceedingly obliged to you for re-electing me on this occasion. I hope to do all that is possible to justify your confidence hereafter.

Dr. WALLER: Sir John Pender, I beg to move

"That Mr. Henry Dever and Messrs. Welton, Jones and Co. (formerly Messrs. Quilter, Welton and Co.), both of whom now retire, be, and they are hereby, re-elected auditors of the Company for the current year at a remuneration of £100 each."

In proposing this resolution I will take permission, being on my legs, just to make these observations—that very often out of evil comes good, and that the shareholders are very much indebted to you for some of the statements you were good enough to make in regard to your action as Chairman; and we all think that your journeyings about, however inconvenient to yourself, are vastly remunerative to the Company. You made use of a very true expression at the beginning of the meeting. You said that cables, like men, grow old. I do not know much about cables, but I ought to know something about men, considering the length of time I have mixed with them I know of only one exception to the statement about men growing old, and that exception is our honoured Chairman, who, in my opinion, is labouring under the "chronic disease" of vigorous prime. Long may he continue to do so, and to give that service to the Company which has made it the greatest telegraph company in the world.

Mr. FOX: In seconding the proposal which this gentleman has moved, I also support very warmly the way he has spoken of our Chairman. I feel that the Company is very much indebted to the Chairman for what he has done in advancing our interests. I only hope it will not be very long before he will be able to advance our interests in the House of Commons, as he did before.

The CHAIRMAN: I will read the resolution. Having read it, he put it to the meeting, and declared it carried unanimously. Addressing Mr. Burney, he added: I made a mistake just now in replying to your

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question. What I meant to say was that all the shares were taken. The debentures are not all issued, and we are not dealing with them yet.

Mr. BURNEY: I think you offered them to the shareholders at the last extraordinary meeting.

The CHAIRMAN: There is a portion still to be issued. There are also the South African Company's debentures. We do not want the money, and are not pressing the issue; but if any shareholder will apply at the office we will give him any information he wants on this matter.

Mr. BURNEY: I see that the Five per Cent. Debentures stand at 103, 104, and I was wondering how the Four per Cent. Debentures would be taken up at par.

The CHAIRMAN: I have not the least doubt that when we want the money we shall get it at par. As you are aware our Eastern Four per Cent. Debentures stand high in the market.

Mr. BURNEY: Yes, I am aware of that.

The CHAIRMAN: Well, while it is not a guarantee, so long as there is a shilling in the exchequer of the Eastern Company I do not think these debentures will suffer That is all our business.

Mr. BURNEY: I beg to move that we pass a vote of thanks to the Chairman for his able conduct in the chair to-day.

The CHAIRMAN: I thought, from the complimentary way in which Dr. Waller spoke he had for the moment moved that vote of thanks.

Dr. WALLER: I should have have done it, but I did not like to speak too much.

The CHAIRMAN: It was a very warm expression of opinion indeed, which I feel very much, coming from you and the seconder, and on behalf of my colleagues and myself I desire to say that we greatly appreciate the confidence you continue to give us. I am sure that the greater the confidence that exists between that side of the table and ours the better for the interests of the Company. We have never hidden anything from you; we have given you every opportunity of judging of questions on their merits, and we shall continue to do that as long as we conduct the affairs of the Company. I thank you very much.

The proceedings then terminated.

The Direct United States Cable Company (Limited).

The twenty-third ordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on the 25th ult., Sir John Pender, K.C.M.G., presiding.

The SECRETARY (Mr. T. Finnis) read the notice convening the meeting and the minutes of the last ordinary general meeting, which were confirmed by the present meeting and signed by the Chairman as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said: As usual, gentlemen, I will give you some details, in addition to those mentioned in the report in your hands—a report which is rather full than otherwise. The revenue for the half-year to December 31st, after deducting out-payments, amounted to £34,188. The working and other expenses, including income-tax, but exclusive of cost of repairs, were £16,476, leaving a balance of £17,712 as the net profit of the half year. Adding to this balance the sum of £6,071, transferred from the reserve fund account for dividend purposes to 30th June (that is, to the end of our last financial year), the total becomes £23,783, which has been appropriated as follows:—Final dividend of 2s. per share for the quarter ended 30th June, 1888, £6,071; interim dividend of 2s. per share for the quarter ended 30th September, 1888, £6,071; together £12,142, leaving a balance of £11,641 on the revenue account. A further interim dividend of 3s. 6d. per share for the quarter ended 31st December last, being at the rate of 3½ per cent. per annum, has been declared, and the dividend warrants will be posted this evening. This will require £10,624, leaving a balance of £1,017 to carry forward. The revenue for the half year (which included only four months at the 1s. rate, the 6d. tariff having been in force up to the end of August) shows an increase of £11,185 over that of the corresponding period of 1887; but no reliable comparison is afforded by these figures, because the 6d. tariff was in force throughout the whole of the six months to December, 1887. The 1s. tariff, however, has brought about some reduction in the volume of the traffic, as was naturally to be expected, but the earnings so far have been fairly augmented. The expenses in London, compared with the corresponding period, show as follows:—A reduction of £249 in salaries, increase of £107 in printing and stationery, £40 in office expenses, and £14 in stamps, these increases being wholly chargeable to the alteration of the tariff, which has involved the preparation and issue to nearly all parts of the globe of a very large number of tariffs and other notifications. The expenditure at the stations, including, of course, the additional new station at Boston, compares as follows:—A reduction of £294 in salaries and of £115 in printing and stationery. An increase of £399 in maintenance is due chiefly to some rather extensive repairs to instruments which had to be sent from Nova Scotia to London for repair, and which should not require further outlay on them for some time. Travelling expenses stand at £132 increase, through necessary transfers of operators at stations, which did not take place in the corresponding period of 1887. The increase of £243 in repairs and renewals to buildings, &c., is accounted for chiefly by extra repairs made during last summer to the buildings forming the Company's Ballinskelligs station. The remaining stations' expenses are practically unaltered. In the other expenses, directors' fees are reduced by £157, but the item of "use of patents" increased by £196, payment of royalty having had to be made while the cable was under repair. £233 has been written off for depreciation of spare cable and cable tank, and £271 stands for cost of storage and insurance of spare cable. These two items did not appear in the expenses of the corresponding period. This fact, and the special outlay for repairs above referred to will more than account for the difference of £610 in the expenditure as a whole, as compared with December, 1887, when the expenses were reduced to a minimum. The reserve fund account, after being credited with the interest on the investments and profit on securities realised, and being debited with the outlay on the removal to Halifax and the cost of deep sea repairs, now stands at £239,206. The special expenditure on the removal and the deep sea repairs ought to be recouped to the reserve fund as soon as convenient. The investments continue, as heretofore, to be worth considerably more than they are stated at in the balance-sheet. We have given you very full details of the expenses and the ups and downs that have taken place in the past half-year, and I will now proceed to make a few remarks upon our position since I last had the pleasure of addressing you. We were then in the midst of a most important repair. We had secured one end of the cable, and that was at a depth of over 2,000 fathoms. We then had very bad weather indeed in the Atlantic; but notwithstanding the bad weather—of course it prolonged the operation—we picked up the other end of the cable, and we have now got what I may call a very perfect cable indeed. During the last day or two we have resumed duplex working, and our power is now almost double what it was in the past three or four years. That is fortunate in many respects, and it places us in a position to take a very important part in the work which is being now operated. When I last addressed you we were also in the midst of another business—that was the settlement of the tariff—whether it was to be 1s., or what it was to be. I think the opinion was very strong indeed on the part of the Anglo Company and this Company that we should go to 1s. So far we have not been disappointed in the 1s. tariff; but I may tell you that we do not get as much money as we ought to get out of the 1s. tariff to pay a fair dividend. However, we are getting about double the money we were getting during the last four months of the 6d. rate, and I am hopeful, when people get accustomed a little more to the extra 6d., that the traffic will go on increasing. The commerce of the world, as you know, is now conducted more or less by submarine telegraphy—that is to distant places—and the growth of the traffic must continue if the country grows. We already see a very marked growth, and it is very important to have established the fact that we receive from the 1s. tariff nearly the same amount of traffic that we had under the 6d. tariff. We are giving the telegraphing public a fair trial of a very cheap rate, and I hope that no alteration in the future will be necessary. In regard to our cable, I think we have every reason to be proud of the way in which the Direct Cable Company has stood its own during all this time. Another cable company—a single cable company—the French Company, is in a very different position to what we are in. We stand with a good reserve fund, with a renewed cable, probably as good for our purpose as the day upon which it was laid. We have put in a considerable amount of new cable in the deep water portion, and I think we are probably standing in as good a condition as any cable company can stand. We have effected considerable changes, which are noticed in the report. We have reconstructed the working of our Company, and have, I think, put it in a position quite as efficient as any existing cable company. We have taken away our office from Chester to Liverpool, but having re-established the duplex system upon our cable, we have, in connection with that duplex system, recognised the people who were working at Chester. The reconstruction has effected a considerable saving. We have also placed the management of the Company in a position which has effected another saving of at least £1,200; and I repeat that, looking to the management of the Company from first to last during all this period of hard times, I think we have come before you to-day showing that we are now, I hope, making a fresh departure, with our cable restored, and with a fair and moderate tariff, and we are able to take our part in this work quite as well as any of the other cable companies. With these remarks I beg to move the following resolution:—

"That the report of the Directors dated 11th January, 1889, together with the statement of accounts to the 31st December, 1888, annexed thereto, be, and the same are hereby, received and adopted."

Mr. WILLIAM FORD seconded the motion.

Mr. JACKSON thought that the results of the 1s. tariff so far should be eminently satisfactory to the shareholders. There must be in all their minds a conviction that their position was growing better. The Chairman had not mentioned a circumstance that it was very important for the shareholders to know. In the report of the Anglo-American Company they were informed that there was something like an agreement between the "pooling" companies for 12 months. That was a stroke of policy upon which the Board should be congratulated, as well as upon the present position of the Company. He thought that the contracts for repairs should always be open to tender from the large companies. He wanted to point out the extraordinary fact that the Direct Cable repairs for the last year cost £58,000, whereas those of the Anglo-American Company—and he thought that company had far more breakages—were represented by £21,000. The Anglo-American Company possessed certain advantages over the Direct Company for repairs, but still the figures showed so great a difference that he hoped this would be the last time that any contracts would be given to any company unless by tender.

Mr. GUESDON said he had always been an advocate for cheap tariffs, believing that low prices in every thing increased consumption. High profits always tempted competition, and hence three cables had been established since the Direct Company was secured by the Chairman. He agreed with the previous speaker that they ought always to invite tenders for cable repairs.

The CHAIRMAN: I will reply to the honourable shareholders. Mr. Jackson is an old stager. He has just told us he has been connected with the Company from the very beginning. As he occasionally pays a visit to the office, I think he ought to be rather better informed than he is to-day. I will take the last part of his statement first. He ought to have been aware that we did invite tenders for the repair of the cables. We

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had tenders from three of the very first companies, and we submitted those tenders to an eminent firm of consulting engineers, and they reported as to the tender we ought to accept, and that was the tender we did accept. One of the tenderers came to me afterwards and said (for I explained the whole matter to him), "I think you are perfectly right in having accepted that tender; they were people who could do it better and cheaper from their knowledge than any of the other parties." That I think most satisfactory. You cannot, therefore, teach us what we ought to do. We have done a very great deal indeed for the Direct Company. When it came into our hands it had been four years in existence. It had a debt of £100,000 hanging over it, which was very likely to strangle it. It was going down every day, and when we stepped forward to rescue it, we rescued it when it was all but wrecked. We brought it into condition almost immediately. We have from the first time we took charge of it up to the late reduction of rates, when the strong competition began, paid our shareholders 5 per cent. upon the £20 shares, and we have put aside a quarter of a million of reserve fund. If that is not good management, I do not know what good management is. As to its being an unfortunate company, I admit that in the first stages it was very unfortunate—unfortunate in its cable, unfortunate in working it; in fact, it was a series of misfortunes and unfortunately nearly every shilling of the original capital was lost. We did save some of it, however. When we took possession of the Company its shares were £4 or £5. They are now about £10, and when we compare ourselves with the French Company and see their £20 shares at £4, ours being as I said at £10, I put it to any fair-minded man whether our position has not very much improved. I put that to the gentleman more particularly who addressed us on this subject. He used to give us credit, but he gives us no credit now. However, he has got some idea that I am overstraining and overworking myself; but depend upon it there is no want of vitality, in any shape or form, either on the part of myself or any member of the Board, in conducting the affairs of the Company in a thoroughly efficient way, and it will compare with any existing submarine cable company. I think that that is a sufficient answer, and I think my friend will accept that.

Mr. JACKSON said he did not go into the ancient history of the Company. What he remarked was that whereas the repairs of the Anglo-American Company, for a larger number of breakages, cost £21,000, those of the Direct Company cost nearly £60,000, and he thought that some explanation was due to the shareholders as to the difference. He contended that they were entitled to investigate that unsatisfactory feature of their affairs.

The CHAIRMAN: I am very much astonished at the hon. gentleman's statement. If the question were put to Mr. Weaver now he would tell you that they have spent in the Anglo Company on a single repair in the Atlantic over £80,000. Over £80,000 has also been spent in repairing the French cable at different times. You are comparing a great and important repair—perhaps the most important repair ever made in a submarine cable—with ordinary repairs of cables in the Atlantic. There is no comparison.

Mr. JACKSON: There is some comparison. The repair of the Brest cable was a more difficult matter.

The CHAIRMAN: I am rather surprised at my friend, whom I have recognised as rather an authority in submarine cable matters. His want of knowledge to-day shows me that he has not been giving the attention to these matters that he used to do when in business. I think I have answered to the satisfaction of the shareholders the questions put to me. He then put the motion in the usual way, and it was carried unanimously.

On the motion of Mr. JACKSON, seconded by Mr. JOHN VARLEY, a vote of thanks was unanimously accorded to the Chairman and Directors.

The CHAIRMAN, in reply, said: I am very much obliged to you for the way that my name has been received, and I thank you on behalf of myself and my colleagues. We are here to do our duty to the shareholders and to the telegraphing public generally. As long as we do that we are satisfied that men who look at these things from a fair and just point of view will not refuse to accord us what is our due.

The proceedings then terminated.

Metropolitan Electric Supply Company (Limited).

An extraordinary general meeting of the members of this Company was held at the offices, Winchester House, Old Broad-street, on the 25th ult., Sir John Pender, K.C.M.G., in the chair, for the purpose of confirming the resolution of the extraordinary general meeting, held on the 8th ult., altering Clauses 26, 45, 102, 119, 121, 123, 130, and 155 of the Articles of Association of the Company, as published in *The Electrician* on Jan. 11th.

The SECRETARY (Mr. E. Cunliffe Owen) read the notice convening the meeting.

The CHAIRMAN: Gentlemen, you have heard the resolution read, and this meeting is called for the purpose of confirming it. He then moved the confirmation of the resolution.

Mr. J. C. PARKINSON seconded the motion.

The CHAIRMAN put it in the usual way, and having declared it carried, added: We are going on with our installations as quickly as we possibly can. We have now one station at work, and two others are in course of construction, and we expect that they will be ready by April. Mr. Gordon tells me that we have settled the contract with the Grand Hotel and the Hôtel Métropole to supply them from the existing station at Whitehall. My impression is that we shall have more demands upon us than we shall be quite able to supply for some considerable time. However, if energy will meet the whole of the requirements there will be no want of that.

Anglo-American Telegraph Company (Limited).

Report of the Directors to the ordinary general half-yearly meeting of the proprietors, to be held at Winchester House, Old Broad-street, London, E.C., this day (Friday) at two o'clock:—

1. The total receipts from the 1st July to the 31st December, 1888, including the estimated balance of £390. 12s. 8d. brought forward from the last account, are estimated at £131,186. 6s. 11d. This amount is, however, subject to revision upon settlement of the accounts with the Paris-New York Telegraph Company. The traffic receipts show an increase of £35,352, as compared with the corresponding period of last year.

2. The total expenses of the half year, including repair of cables, &c., as shown by the revenue account, amount to £51,110. 13s. 11d.

3. Interim dividends of 7s. 6d. per cent. on the Ordinary stock, and 15s. per cent. on the Preferred stock, were paid on the 1st November last, absorbing £25,250, leaving an estimated balance of £53,825. 13s., out of which the Directors recommend the proprietors to declare final dividends of 15s. per cent. on the Ordinary stock, and £1. 10s. per cent. on the Preferred stock, amounting to £52,500, making a total distribution for the year ended the 31st December, 1888, of £1. 12s. 6d. per cent. on the Ordinary stock, and £3. 5s. per cent. on the Preferred stock, leaving an estimated balance of £1,325. 13s. to be carried forward to the next account.

4. The Company's repairing ss. "Minia" has been engaged during the past half year in the repairs of the Brest-St. Pierre cable, the St. Pierre-Duxbury cable, the Southern Placentia-Sydney cable, the tricore Placentia St. Pierre-Sydney cable, the Prince Edward Island cable, and the shore end of the 1873 cable at Heart's Content. The Brest-St. Pierre cable was broken in four places, two of the faults were in deep water, and two in shallow water. The total cost of the repairs to the Brest-St. Pierre cable amounts to £21,924. 15s. 3d., all of which has been charged to the renewal fund, a large quantity of cable having been expended in the renewal of the line. The interruptions to which the St. Pierre-Duxbury cable has constantly been subjected by the anchors of fishing vessels have decided the Directors to divert and renew a considerable length of the line during the course of the approaching season. The cost of this work will also be chaged to renewal fund.

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5 The Company's system of cables and land lines is in good working order, with the exception of the North Placentia-Sydney cable and Island Cove cable, both broken within the last few weeks.

6. The litigation between the Anglo-American Telegraph Company and the Paris and New York Telegraph Company is still pending, the points referred by the Paris Court of Appeal to the Conseil de Prefecture de la Seine for interpretation not having yet been heard.

7. A memorandum of agreement was entered into on the 30th July, 1888, between the Anglo-American Telegraph Company (Limited), the Direct United States Cable Company (Limited), the Western Union Telegraph Company, La Compagnie Française du Télégraphe de Paris à New York, the Commercial Cable Company, and the Postal Telegraph Cable Company, by which the tariff for messages between Europe and New York and Canada was increased from 6d. to 1s. per word, and to 5d. per word for Press messages. The new tariff came into force on the 1st September last, and is to continue for one year certain, thirty days' notice by either of the parties being necessary to determine the same.

8. It is not possible to say after so short an experience whether the 1s. rate will ultimately become a financial success, but so far the results may be considered as fairly satisfactory. The first four months of the 1s. rate, as compared with the last four months of the 6d. rate, show an increase of 111 per cent. in the revenue, and a decrease only of 11 per cent. in the volume of traffic. As compared with the corresponding four months in 1887, an increase of 77 per cent. is shown in the revenue, and a decrease of 26 per cent. in the volume of traffic carried. The differences between the several periods compared are largely due to the normal variation of traffic during the months under consideration, and to the proportionate alterations of percentage in the amounts paid out to connecting companies, under the 6d. and 1s. rates respectively.

9. In accordance with the Articles of Association, two Directors of the Company, Sir James Anderson and Mr. William S. Cunard, retire at this meeting, and, being eligible, offer themselves for re-election.

10. Mr. Joshua Dean and Mr. Francis Glass, the auditors, also retire, and offer themselves for re-election.

Cuba Submarine Telegraph Company (Limited).

Report of the Directors for the half year ended 31st December, 1888, to be presented at the thirty-fifth ordinary general meeting of shareholders, to be held on Wednesday, the 6th February, at one o'clock.

2. From these it will be seen that the gross receipts (including the balance brought from last account) amount to £21,904. 12s. 10d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable) to £6,395. 16s. 11d., leaving a sum of £15,508. 15s. 11d. to the credit of revenue account.

3. Of this the sum of £4,000 has been added to the reserve fund, increasing that fund to £84,000.

4. The dividend on the Preference shares will absorb £3,000, and leave £8,508. 15s. 11d., out of which the Directors recommend the payment of a dividend on the Ordinary shares at the rate of 9 per cent. per annum, free of income-tax, the balance, £1,308. 15s. 11d., being carried forward to the current half-year's account.

5. The cables have continued in good working order throughout the half-year, although the Cienfuegos-Batabano section is showing signs that some repairs may shortly have to be made upon it.

Taunton Electric Lighting Company (Limited).

Report of the Directors to be presented at the second annual general meeting of the Company, to be held at the Castle Hotel, Taunton, on Monday, February 4th, at six o'clock p.m. :—

The number of shares allotted is 954, on which the sum of £4,750 has been received. The accounts for the year show a profit of £355. 18s. 3d. Your Directors recommend that a dividend of six per cent. be paid, free of income-tax. This will take £272. 0s. 5d. The balance carried on for a reserve and depreciation account, including the amount from 1887, will be £207. 13s. 9d. In addition to the Taunton business, the Company has carried out temporary installations in Bristol, Bath and Exeter.

Deputations from various places have visited Taunton during the past year for the purpose of inspecting the Company's works and the lighting arrangements of the town, the general testimony being that it is the most successful installation in central station lighting yet carried out in the United Kingdom. The machinery has been maintained in excellent working order, those portions of it which are continuously wearing out being made good and charged to income account. The present engines are rather extravagant in their consumption of fuel : your Directors therefore recommend that as the demand for private lighting is rapidly increasing, engines of the highest possible efficiency should now be put down, using the present engines as duplicate plant only. This will effect a saving of nearly £200 per annum in coal, water and oil. It is desirable, also, to largely increase the electrical plant, to enable your Directors to cope with the increasing business, and they therefore propose to offer at par the remaining share capital of the Company.

Should the applications for shares exceed the number offered, the present shareholders will receive priority of allotment in proportion to the number of shares they now hold. A form of application for shares is issued with the balance-sheet. Three of the Directors retire by rotation, and are eligible for re-election, namely, Messrs. Bale, Withycombe, and Potter. The auditor, Mr. Albert Goodman, retires, but is eligible for re-election, and offers himself accordingly.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 25th amounted to £5,435.

EASTERN TELEGRAPH COMPANY (LIMITED).—Notice is given that the share certificates for the New Ordinary Shares will be ready for delivery, in exchange for banker's receipts, on and after the 4th February next.

NATIONAL TELEPHONE COMPANY (LIMITED).—The accounts of this company made up to December 31, show a gross revenue of £117,726, as compared with £99,563, and the directors have declared a dividend for the six months ended December 31st last at the rate of 6 per cent. per annum on the First and Second Preference shares, and an interim dividend at the rate of 4 per cent. per annum (being at the same rate as for the corresponding period) on the Ordinary shares, carrying forward £10,399, of which £3,500 is set aside against an outsanding claim. The unaccrued revenue carried forward amounts to £54,385, as against £45,826, at the same period of the previous year.

THE DIRECT SPANISH TELEGRAPH COMPANY inform us that direct cable communication with Spain is restored.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this company for the week ended January 25, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,550.

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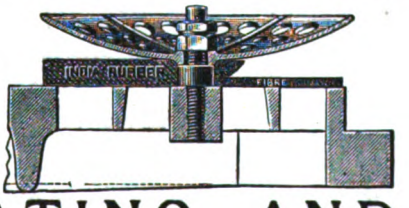

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name.	Price, Wednesday, Jan. 30, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Jan. 30, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
1,770,360	Stock	7/6	Anglo-American	50 51	2 13 5	Jan., Apr., July, Oct.	50⅛	...
2,614,820	Stock	15/0	Do. Preferred	84 85	3 4 8	" "	85	84
2,614,820	Stock	5/0	Do. Deferred	17 17½	...	February	17½	17 7/16
130,000	£10	3/0	Brazilian Submarine	13½ 13¾	5 1 10	Mar., June, Oct., Dec.	13½	13½
112,900	£100	5%	Do. 5 per Cent. Bonds	102 105	4 15 3	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 14¾	5 15 3	February and August	14¾	...
6 000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	" "	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3 4	3 10 0	March & September	3½	..
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	..
60,710	20	3/6	Direct United States	9¼ 10¼	3 19 0	Jan., Apr., July, Oct.	10⅛	9⅞
380,000	10	2/6	Eastern	12⅝ 12⅞	4 13 2	" "	12⅝	12⅜
70,000	10	3/0	Do. 6 per Cent. Preference	14¾ 15½	3 16 8	" "	...	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	108	107½
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	108 111	4 10 1	February & August	...	...
250,000	10	2/6	Eastern Extension	12¾ 13	5 0 0	Jan., Apr., July, Oct	13	12⅞
300,000	100	6%	Do. 6 per Cent. Debentures, 1891	104 106	5 13 2	February & August	105	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	101 104	4 16 2	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust	6⅞ 7⅛	5 5 3	Jan., Apr., July, Oct.	7 3/16	6 15/16
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	" "	14⅜	14 5/16
150,000	10	5/0	Great Northern	14½ 15	3 6 8	Jan., July, and April	15	...
17,000	25	2/6	Indo-European	38 40	6 5 0	April and October	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
15,609	10	3/0	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	96 99	5 1 0	March & September	99	98½
30,000	10	6/0	West Coast of America	8¼ 9¼	6 9 9	January and July	9	...
150,000	100	8%	Do. Debentures 8%	117 121	6 12 3	June and December	...	...
88,321	10	nil.	West India and Panama	1⅝ 1⅞	...	...	1⅞	...
34,563	10	12/0*	Do. 1st Preference 6%	11⅜ 11⅝	5 2 2	April and October	11 3/16	11⅜
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	12⅝ 13	5 15 3	March & September	12 11/16	12⅝
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅝ ¾	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	7/16 7/16	3 2 11	...	...	...
80,000	5	5/0	United	14⅛ 14⅜	5 5 3	June and December	14⅜	14⅜
55,000	5	3/0	United River Plate	5⅓ 5⅔	...	January and July	5⅔	5 1/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3¼ 4	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4½ 5	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	...	...
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
87,350	12	12/0	Telegraph Construction and Maintenance	42 43	5 11 7	March and July	42¾	42½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17½ 18½	5 11 1	February & August	19	18⅝

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

The Committee of the Electrical Trades Section of the L.C.C., at their meeting on Monday last, had under consideration the very important question of the possibility of inducing manufacturers of electrical apparatus of all kinds to conform, so far as possible in the matter of voltages, gauges, &c., to certain standard types. The great advantage—both to the trade and to the public—which would follow from the general adoption of such standards is so evident that there can be no need to insist upon it here. The prevailing system, or rather want of system, is a continual source of worry and expense to every one concerned. Take the case of voltages alone—we believe we are correct in stating that the Edison-Swan Company has manufactured lamps to order during the last twelve months of *over one hundred* different voltages. It is surely impossible to believe that any sound reason exists, either scientific or economical, which can cause a demand for such a multiplicity of types. The same thing applies with perhaps even greater force to dynamos. It is an understood thing that if manufacturers could settle down to a limited number of types the profits of the trade would be immensely increased. As it is, they are constantly engaged in designing and building special machines to meet the requirements of specifications which are often drawn up apparently without either rhyme or reason.

But although there is no room for dispute as to the existence of the evil, it is quite another thing to find an efficient remedy. The question is one of the greatest difficulty and of no little delicacy; and this is fully recognised by the Committee. If there is one thing more certain than another to annoy an Englishman it is for anyone else to suggest to him how he should manage his own affairs, and the Committee are most anxious that it should be clearly understood that they have not the slightest intention of taking any action which could be so construed. On the contrary, all that has been done so far is to nominate a widely representative Special Committee — consisting of a large number of manufacturers and contractors—who are merely requested, in the first instance, to consider whether it is advisable to attempt anything of the kind indicated, and if so, how best to proceed. Several members of the General Committee, whilst recognising the great advantages to be gained, expressed a fear lest the provincial manufacturers, and particularly those who do not happen to be members of the Chamber, might feel that their interests had been ignored. To avoid any such feeling it should be clearly understood that the Section is anxious to listen to the views of everyone concerned, and in any case nothing will be done in a hurry, nor without the fullest consideration. It is, in fact, evident from the nature of this question, that nothing effectual *can* be done unless a practical unanimity is arrived at. For our own part we are convinced that the effort is worth making, and although we do not conceal from ourselves the extreme difficulties with which the question is beset, still in view of the markedly conciliatory and sensible tone in which it has been taken up, we by no means despair of a solution.

The local authorities of no less than four important districts have issued reports on electric lighting within the last few days. The City report and that of the Kensington Vestry (both of which we print on another page) are on the whole very favourable to the immediate prospects of electric lighting in the metropolis. On the Kensington report we have something to say in our leader. Abstracts of the Brighton and Birmingham reports will be found in the Notes; they are both of an unfavourable character.

In view of the somewhat disappointing character of the discussion which followed the reading of Prof. Jamieson's Paper on "Insulation Resistance in Installations," it would seem almost a pity that the Institution of Electrical Engineers is to devote another night to the same subject. As a matter of fact, we are inclined to think that Prof. Jamieson has already said all that *can* be usefully said on the subject at the present time. What would now appear to be wanted is that the example which he has set in taking actual measurements of insulation resistance should be widely followed. It is difficult to see that any really useful result is to be attained by the mere expression of opinion as to the best value to give to the insulation coefficient. What we do want is a wide collection of data from actual practice; in this way only can we discover not merely what ought to be done, but what can be done, and what is being done under the conditions with which contractors have actually to deal. If Prof. Jamieson's Paper leads to such a result it will be difficult to overestimate its value. Since, however, it is to be reconsidered before opportunity has been allowed for further practical observation, we trust that no effort will be wanting to make the discussion worthy of the importance of the subject.

There is one point of considerable importance on which we are inclined to disagree with Prof. Jamieson. Speaking of

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testing with a Wheatstone bridge, he says that if a sensitive mirror galvanometer be employed, "the battery power used need only be a few Leclanché cells (10 or 12 at most)." Now apart from the practical inconvenience (amounting, in fact, almost to an impossibility) of bringing the mirror galvanometer into regular use for such a purpose, we are of opinion that the only really valuable test would be one made with an E.M F. considerably higher than that which the insulation will afterwards be subjected to. And, more than this, the current should be kept on the wire for some considerable time. In this case the galvanometer need not be very sensitive; but the difficulty is of course to get the high voltage. On this point we venture to make a suggestion. It would seem a comparatively simple matter to build a small magneto, with the armature geared to a train of wheels, and arranged to be driven by a weight. It would even be easy to get different E.M.F.s at pleasure by employing a suitable weight as the driving power. It is not our business to go into details, but at present we can see no reason why this should not be done, and it would certainly be far more satisfactory than any method of testing with an E.M.F. perhaps less than 10 per cent. of that which the insulation will be required to stand.

THE Committee of the Institution of Electrical Engineers, which has been appointed at the request of the Board of Trade to confer with it upon the question of overhead wires, is displaying a commendable activity, and already four meetings have been held. Meanwhile the Electrical Trades Section of the L.C.C. is also taking steps to secure a representation of its views before the Board of Trade. Seeing that this is rather a commercial and an engineering than a scientific question, it would seem to have been an oversight on the part of the Board not to have invited the co-operation of the Section.

IT will possibly cause some little surprise to the "local authorities" to learn from a Board of Trade circular that (in the absence of a Provisional Order) they possess no power whatever to grant permission to an electric supply company to place its mains under any "public highway." When the Board of Trade were asked this very question (in December last) by the Ipswich Town Council they were not in a position to reply; since that date they have, however, been advised that the above is the interpretation of the law. It is, moreover, clear that any other interpretation would have done violence to the spirit of the Electric Lighting Acts, whereby the Board of Trade is constituted the sole abiter in all projects for the public supply of electricity, subject, of course, to the confirmation of Parliament. Where the procedure is by Provisional Order the Board of Trade may grant such Provisional Order in despite of the local authority, though the latter may subsequently oppose its confirmation by Parliament.

IT is clear, however, that this circular is chiefly intended as a warning to those Supply Companies who are investing their money in schemes which have not received the sanction of the Board. The existing condition of affairs has, in fact, compelled the Board of Trade to place itself in a position to ignore, if it should think fit to do so, the vested interests which are now being rapidly created. *Beati possessores* is no doubt a legal maxim, but those who attempt to secure a footing in any other way than that provided by the law of the land must be prepared to face the consequences of their temerity. This notification will probably have some tendency to check the present display of activity, but the delay will only be of a temporary character, and will, doubtless, eventually enable every one of the companies who are at present in the field to go ahead with a clear conscience. Anyhow, it was clearly impossible for the Board of Trade to have acted otherwise than it has done.

MR. ACHESON'S photographic experiments, to which our New York correspondent referred last week, seem to have attracted a good deal of attention in the States; but although they are interesting in their way, we fail to see that any new light has been thrown upon the subject. Mr. ACHESON seems to have thought that if he could prove the existence of a time interval between the A and B sparks Dr. LODGE'S theory of the alternative path would be upset. But in accordance with that theory we should expect to find an interval of one-quarter of the oscillatory period when the B spark is at a maximum, and less when the B spark has less than its maximum length. In the absence of information as to the time constant of the circuit it is difficult to judge whether the spreading of the B spark on Mr. ACHESON'S plates could have been due to the displacement indicated. Dr. LODGE'S views, moreover, have passed the test of mathematical analysis; Mr. ACHESON'S have still to be submitted to this ordeal.

THIS week's instalment of Dr. FLEMING'S "Notes on Electro-Magnetic Induction" deals with one of the most interesting of the many interesting results obtained by Prof. HENRY nearly half a century ago. We doubt whether there are a dozen electricians living to-day who were aware of the singular and important effects of "screening" action. The facts will probably be found to be by no means unimportant in the practical development of alternating-current apparatus. The researches of Prof. HENRY would seem to have passed into a wholly unmerited oblivion until they were not only resuscitated by Dr. FLEMING but also interpreted and expounded in accordance with modern theory.

As the English Patent Laws are often compared unfavourably with those of the United States, it is interesting to notice how the comparison looks when viewed from the other side of the Atlantic. The New York *World*, in a series of sensational articles, has lately been giving the United States Patent Office an "airing," and if half of what is alleged against them be true, both office and officers are much in need of it. The charges of fraud and maladministration with which the *World* liberally bespatters the officials are, however, without much substantial evidence to back them. But the Patent Laws themselves appear to work badly, noticeably where they differ most from the British. It is often complained that our indiscriminate system of granting patents lends a fancied security to the poor inventor, tempting him to costly

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expenditure, with the result merely of swelling the Patent Office revenue. In America, on the other hand, where a rigid preliminary examination is instituted, the "poor inventor" has very little chance of a hearing, the examiners considering it their duty to pluck as many candidates as possible; and so much time is occupied in the process that the invention is often rendered useless, or is forestalled by some wealthier and more dexterous applicant.

ANOTHER mischievous system pertains to the United States Patent Laws, which may be worked with great injustice both to the inventor and the public. Briefly, it amounts to this, whenever a valuable patent is obtained some rich company is pretty sure to find out that the invention is not new, and then lends its support to the "prior inventor." If the patentee is poor he is incontinently snuffed out; if rich, both claimants agree to keep up a contest of claims, the Patent Law meanwhile granting both security until their dispute is settled. When this can no longer be delayed the two combine in one "basic" patent, the effect of which is to secure a term of seventeen years' protection *plus* the years during which the parties have been playing at litigation. The *World* alleges that this is the meaning of what has been going on in connection with the telephone patents in America, and that we shall presently hear of an agreement under which a fresh lease of life will be sought for the disputed patents, although they have enjoyed exclusive rights already since 1876.

The West Indies and British Guiana Cable.—We are informed that the cable between Punta Rassa and Key West is interrupted.

The Bessbrook Tramway.—During the past year 97,668 passengers and 12,206 tons of goods have been conveyed over the Bessbrook Electric Tramway.

New Mexican Cable.—Advices from the city of Mexico state that a second cable is to be laid between Vera Cruz and Galveston during the present spring.

Nottingham.—An electric lighting company is now being formed in connection with a London company for the purpose of supplying the town with electricity.

The New Edison Stations.—The *Electrical World* of January 19 contains an excellent description, with illustrations, of the new "uptown" Edison Stations at New York.

The Electric Light in Brazil.—The municipal authorities of Inez de Fora have ordered from the Westinghouse Company of New York the necessary plant for lighting the city by electricity.

The Cupidoscope.—Messrs. J. and C. B. Gibson, of Edinburgh, have brought out an amusing electric apparatus called the "Cupidoscope," which will probably afford much entertainment at evening parties and other social gatherings.

Wolverhampton.—A company is being formed at Wolverhampton for the purpose of supplying the electric light on the house-to-house principle. We understand that Messrs. Elwell-Parker will provide the necessary plant for the first central station.

Electrical Science in Spain.—We have received the first number of a fortnightly journal, entitled *Anales de la Electricidad*, which is issued in Barcelona under the directorship of Dr. Antonio Suarez Saavedra, a name well known in this country.

St. James's Vestry.—At a meeting of this Vestry last week some discussion occurred with reference to the assessment of the premises occupied by the St. James's and Pall Mall Electric Light Company. It was generally agreed that the question of assessment was rather premature, and the matter dropped.

Crompton and Co.—Following a well-established custom, the wives and children of the *employés* of Messrs. R. E. Crompton and Co. were recently invited by Mrs. Crompton to a tea and entertainment in the large joiners' shop of the firm of Crompton and Fawkes. The company numbered about 400, of whom 290 were children. No effort was spared to make the affair a success.

Lambeth Vestry.—At the last meeting of this Vestry a report was read from the Electric Lighting Committee with respect to the applications made by the London Electric Supply Corporation and the Metropolitan Electric Supply Company for Provisional Orders for Lambeth under the Electric Lighting Acts. The committee recommended the Vestry to oppose both the applications. The Vestry adopted the committee's recommendations.

Electric Lighting in New Zealand.—We learn that Mr. J. Ewing is about to light Vinegar Hill, near Dunedin, New Zealand, by electricity. Arc lights of 2,000 candle-power will be used, and supplied with current from dynamos manufactured by Messrs. Elwell-Parker, of Wolverhampton, the machines being driven by Pelton water-wheels under pressure of 400 feet per head. The Cromwell Q.M. Company at Bendigo Gully, lately lit by the same firm, is now in full operation with satisfactory results.

Mr. Halliday's First Course of Mechanical Drawing.—With reference to our review of last week, Mr. Halliday writes us as follows:—"Allow me to thank you for the appreciative notice which you have given of my book on page 368 of *The Electrician*; but I shall be glad if you will allow me to point out that while the book is my own, the idea of making tracing a first course of mechanical drawing is Prof. Perry's, and the system was in successful operation here and in Japan for at least seven years before I came to the college."

St. Thomas, Charterhouse, Boys' School.—The Clothworkers' Company's Technical Scholarship, of the value of £130, has just been awarded to Walter C. Mears, a pupil of the above school. The scholarship is given for proficiency in mathematics, science and drawing, and is held at the Technical College, Finsbury. It has now been won for several years in succession by pupils of this school. It will be remembered that a short time ago another pupil won a Saddlers' Company's Scholarship of £60, and seven others passed the Matriculation Examination of the City and Guilds of London Technical College.

The Bressa Competition.—The Académie Royale des Sciences of Turin announce the close of the competition for the Bressa Prize for the greatest scientific discovery or work during the years 1885-88. This prize was only open to Italians. The Académie at the same time remind the public that a second competition is now open. According to the will of the late Dr. C. A. Bressa this second prize may be competed for by savants of all nations; the value of the prize is 12,000fr., and will be awarded to the most brilliant or useful discovery or to the most celebrated scientific or historical work of the period 1887-90.

St. Luke's Vestry.—On Tuesday afternoon last week the members of the St. Luke's Vestry met specially to consider the proposals of the London Electric Supply Corporation. The Parliamentary and Improvement Committee brought up recommendations favourable to the proposals provided they were carried out by fully authorised and competent companies. They also recommended that a limit be placed upon the time of carrying out the work after powers were obtained, and that there be a sufficient deposit of money in the hands of the Vestry to recoup them for any expenses in reinstating the public ways which might be disturbed for the laying of the system. These suggestions were agreed to unanimously.

An Electric Date and Time Stamp.—An ingenious apparatus by which date and time can be stamped on any document has lately been brought out by a Mr. C. Adams-Randall. The mechanism simply consists of five type wheels disposed on a single axis, and the minute, the hour, the month and the year

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are automatically placed in line under the impression pad. Motive power is obtained by means of a couple of Leclanché cells, actuating an electro-magnet, which puts tension on a spring and moves the minute wheel. Upon the sixtieth movement of this wheel the hour wheel is automatically moved, and so on. The apparatus can be set in motion in connection with any clock. Its first application in this country has been made by the Commercial Cable Company.

Brisbane.—A correspondent at Brisbane informs us that Messrs. Trackson Brothers are actively pushing the telephone in that city. The Bundaneba coal mines have a very complete telephonic installation, the whole of the wiring being in lead tubing on account of the damp. Several large Government offices have also been provided with telephones. At the rifle ranges belonging to the Defence Force the markers and the various firing points are telephonically connected, and the arrangement has given great satisfaction. Another telephone line connects Walloon Station to Marbery Scrub, a distance of 14 miles. Messrs. Trackson Brothers have also put in three small electric light installations during the past year, each of 50 lights, one in a mine and two in sawmills. Parliament House, the Government printing office, and the railway station are lighted by Edison plant.

Globular Lightning.—In a letter to *L'Océan* M. de Paulpiquet gives an account of a somewhat remarkable globular discharge, which was witnessed by him on the evening of the 30th of November last, as he was driving home from Brest. At the height of the storm M. de Paulpiquet suddenly perceived a dark red glow in front of him, caused by a hemispherical body which had fixed itself on to the horse's chest, a little to the right. The part of the hemisphere turned towards the road, however, lit it up with a dazzling white glare. The horse stumbled several times, and on the last occasion the ball burst, killing the horse on the spot. A large oak on the side of the road had been struck and torn open from top to bottom. M. de Paulpiquet was uninjured, but the servant at his side got a severe shock, and a boy who was behind him was thrown out of the trap, and still suffers from a burning sensation in his right ear.

The Centenary of Ohm.—As we mentioned in our last issue a meeting was held on Thursday last week in the meeting-room of the Royal Society, under the presidency of the Right Hon. Lord Rayleigh, for the purpose of appointing a committee to co-operate with the committee formed in Germany to promote the erection in Munich of a statue of George Simon Ohm. The following gentlemen were selected to act on the English committee:—Sir F. Abel, D'Atkinson, Mr. Vernon Boys, Mr. Conrad Cooke, Profs. Ewing, Fitzgerald, Fleming, G. Carey Foster, Mr. Glazebrook, Prof. D. E. Hughes, Mr. Norman Lockyer, Profs. Hugo Müller, John Perry, Mr. W. H. Preece, Lord Rayleigh, Profs. Reinold, Rücker, Stokes, Mr. Swinburne, Sir William Thomson, and Prof. S. P. Thompson. Lord Rayleigh was elected President, Prof. Hugo Müller treasurer, and Prof. G. Carey Foster and Prof. John Perry undertook to perform the duties of secretaries and to receive subscriptions.

The Hanover Square School of Electrical Engineering.—In consequence of the recent re-organisation of the advanced instruction, which is now under the charge of Mr. Charles Capito, M.I.M.E., the managers recently requested Mr. Gisbert Kapp to undertake the examination of the advanced class. One day was devoted by him to an examination in practical work, such as engine-running, boiler-firing, dynamo and lamp management, joint-making, &c., and a second to Papers on mechanical and electrical engineering. Out of seven students examined, three were awarded the certificate of the school, Messrs. Hawkins, Rowlett and Graves; the average percentage of marks gained by them being respectively 87·8, 78·8 and 65·8. A minimum of 70 per cent. in the practical work, and 60 per cent. in the two Papers, is a necessary condition of obtaining the certificate. We may add that, as the result of former examinations, Mr. Fletcher has also recently gained the certificate.

St. Catherine's Lighthouse.—In this week's *Graphic* appears a two-page sheet of admirable sketches of St. Catherine's Lighthouse and its electrical machinery. One in particular shows the lamp, with its fluted carbons, 2½in. diameter, six-pointed star shaped. Upwards of 20 electrical horse-power are consumed in this one single arc, and as absolute steadiness of the arc is vital to the optical requirements of the lantern the form and quality of the carbons become of the utmost consequence. This fluted form of star-shaped section was originally proposed by Sir James Douglas, and its use at St. Catherine's for the heavy currents of upwards of 300 amperes has contributed in no small degree to the success of the light. The carbons are supplied to the Trinity House by Messrs. Lacombe and Co., of Westminster. Fluted carbons are now much in favour for use in projectors and search lights with large currents. We may add that the St. Catherine's Lighthouse was described in *The Electrician* of July 13, 1888, p. 297.

Brighton.—A special meeting of the Brighton Town Council was held on Wednesday, the 30th ult., to receive a report from the General Purposes Committee with reference to the application of the Brighton Electric Light Company (Limited), for a Provisional Order under the Electric Lighting Acts, 1882 and 1888. The committee reported that they had considered the matter carefully, and found that there were many serious objections to the provisions of the Order, such as the continuance of overhead wires, and the proposed system of charging for electricity. The most serious question, in the view of the committee, was that of the breaking up of the roads and pavements. Attention was also drawn to the fact that in 1883 the Corporation had obtained a Provisional Order, but that the powers of the Order had not hitherto been exercised, in consequence of the uncertainty surrounding the question. The committee was further of opinion that the Council might shortly be able to commence the supply of electricity without incurring serious risk of loss. The committee considered that the Council should refuse their consent. After some discussion this motion was carried.

Electric Motors for Felling Trees.—Hitherto machines for felling trees have been driven by steam power, but this is sometimes inconvenient, especially in thick woods, and electric power has recently been adopted in the Galician forests. Usually in such machines the trunk is sawn, but in this case it is drilled. When the wood is of a soft nature the drill has a sweeping motion and cuts into the trunk by means of cutting edges on its sides. The drill is actuated by an electric motor mounted on a carriage, which is brought up close to the tree and shackled to it. The motor is capable of turning round its vertical axis; and the drill is geared to it in such a manner that it can turn through an arc of a circle and make a sweeping cut into the trunk. The first cut made, the drill is advanced a few inches and another section of the wood removed in the same way until the trunk is half severed. It is then clamped to keep the cut from closing, and the operation continued until it would be unsafe to go on. The remainder is finished by a hand saw or an axe. The current is conveyed to the motor by insulated leads brought through the forest from a generator placed in some convenient site.

An Application of Electricity to Mining.—In a Paper recently read at a meeting of the Ohio Institute of Mining Engineers reference was made to applications of electricity in mining, and the installation of electric power at the Drain Colliery, Osceola, Pennsylvania, was brought forward as a recent successful instance. In this colliery there is an electric motor for the operation of a coal cutter of the type and patent known as a "Lechner Hercules." In this installation a 10-horse-power motor is mounted on a truck, which is placed on the mine tramway, and as the motor weighs less than 1,000 lbs. it is easily moved as the occasion requires. The motor is connected with the cutter by a tarred hemp rope, the connection being of sufficient length to operate the cutter at a distance of 30 feet. The dynamo generating the current is 1,600 feet away from the motor. Only two men are needed to operate the plant, and these two men excavate 100 tons each ten hours. Seventy per cent. of the primal energy is given off for work from motor pulley to the cutter. The cost of the electrical equipment for this service, including generator, conductors, and motor, was £325. The installation was put in by the engineers of the Sprague Company.

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The Occlusion of Gases in the Electrolysis of Sulphate of Copper.—In a recent number of the *Comptes Rendus* M. A. Soret has a Paper giving the results of his investigations into the occlusion of gases by electrolytically deposited copper, which, in view of the development of the Elmore process, possesses an additional interest. In very dilute solutions, says M. Soret, a muddy deposit is usually obtained unless the current density is small; this muddy deposit probably contains a certain amount of copper hydrate. In concentrated solutions, on the other hand, this brownish-black deposit is not found unless the current density is excessive. The deposit is generally bright and metallic, but its degree of malleability is very irregular, being dependent on the temperature and acidity of the electrolyte. Lenz noticed the presence of gases, especially hydrogen, in electrolytically deposited copper, and the result of the analysis of a very brittle deposit gave the proportion of gas at 4·4 volumes. M. Soret's investigations have led him to the following conclusions: 1. Electrolytically deposited copper always contains a certain amount of gas which consists almost exclusively of hydrogen; it also contains a little carbonic acid, and at times a very feeble trace of carbonic oxide. 2. There is a certain relation between the quantity of gas occluded and the temperature and acidity of the solution, which in turn affect the malleability of the metal. 3. In consequence of this relation the gas occluded is a variable quality, and the figure given by Lenz can only refer to the particular case then under consideration. In no case did the hydrogen occur in other than an occluded condition. M. Soret adds: "I propose to follow up these researches upon the following lines: Electrolysis will be performed in concentrated solutions, containing variable amounts of free acid and kept at perfectly constant temperatures during the experiments; the deposited metal will then be submitted to a high temperature in vacuo, and the gases given off will be analysed.

Dr. Lummer's Photometer.—Before a recent meeting of the Berlin Physical Society, Dr. Lummer read a Paper on Photometers, and deduced, from the experiences gained with the existing instruments, the following as requirements in their construction: in the first place, the surfaces whose brightness of illumination is to be equalised must not be separated by even the narrowest intervening space; and in the second, the outline of the surfaces must be sharply defined. The first of the above requirements is satisfied in Bunsen's grease-spot photometer, but not the second. A further drawback arises from the fact that the grease-spot reflects light, and the paper allows some to pass through, so that both the spot and the surrounding surface are always illuminated by both sources of light. An ideally perfect photometer ought to reflect no light from its grease-spot, and be impermeable to light over the rest of its surface. The speaker, working in conjunction with Dr. Brodhun, had obtained the above desiderata by purely optical means. When two total reflection prisms are placed with their hypotenuse surfaces in juxtaposition, and two of the surfaces of the glass-cube thus formed are illuminated by light from bright surfaces, then on looking through the combination of prisms the only light which reaches the eye will be that which enters laterally, whereas that which enters from the opposite side cannot reach the eye. When a drop of Canada-balsam, whose refractive index is very nearly the same as that of the glass, is placed between the opposed hypotenuse surfaces, total reflection is done away with at the place where the drop lies, and thus by illumination from *one* side only a bright spot is seen on a dark ground or a dark spot on a bright ground. When the illumination is made from *both* sides, equality of illumination can be easily established by adjusting the relative distances of the sources of light until the spot disappears entirely. The drop of Canada-balsam very soon loses its sharply-defined edges, hence some other mode of procedure became necessary. The central portion of the hypotenuse surface of one of the total reflection prisms was left untouched, while the rest of the surface was ground to a slightly spherical shape. When the surfaces of the prisms were now firmly pressed together, light passed without hindrance across the point of close contact of the surfaces, whereas it was totally reflected at all other points. By this means an ideally perfect "grease-spot" was obtained, which was permeable to light, but reflected none, while the surrounding area reflected light completely and allowed none to pass through. A third method for obtaining an ideally perfect grease-spot consisted in etching figures on one of the reflecting surfaces of the prisms; the etched portions were perfectly transparent, the rest of the surface reflected light completely. The speaker exhibited photometers constructed according to the above methods, and proved theoretically that the ideally perfect grease-spot bears to the real one the ratio of 1 to 2, according to the constants determined in the Imperial Physico-Technical Institute. The sensitiveness of the new photometer is about 1 per cent.

Electric Lighting in Birmingham.—After a prolonged consideration of the proposed electric lighting scheme, referred to them for investigation, the General Purposes Committee of the Birmingham Town Council have decided to recommend the Corporation not to give its sanction to the Electric Light and Power Order applied for by Messrs. Arthur Chamberlain and George Hookham unless they consent to the modifications suggested by the committee. The Order contained two areas, schedule A comprising the principal business streets of the city, schedule B containing the whole of the city area, for purposes of extension. The main subject of disagreement centred upon the question of giving the undertakers at the outset powers embracing the entire area of the city. The view of the sub-committee was that the area should, in the first instance, be limited to one of the scheduled districts until the enterprise had been sufficiently tested by practical experience. Among the incidental objections taken to the scheme was the fixing of the capital, in the event of a limited liability company being formed, at not less than £50,000. In the opinion of the sub-committee the capital should be double that amount for schedule A alone. It was also thought that the deposit of £1,000 was too small in consideration of the fact that, under the third paragraph of section 9, the sum deposited was to be released when equal amounts had been expended on works. As a security for execution of works, Messrs. Chamberlain and Hookham offered to postpone exercising the powers to be given them by the Order until they have expended in premises, machinery, plant, and instruments a sum not less than £17,500, or until they have assigned the undertaking either to an existing or newly formed company of a private nature in which capital of not less than £50,000 shall be specially hypothecated against works. Of this offer no notice was taken by the committee. Another difference of opinion arose on the facilities to be given to the local authority for the testing of the light. The Chelsea Electric Light Order of 1886, to which appeal was made on different points, provided for the inspection of the insulation and conductivity of the electric lines, the efficiency of the joints, and for making such tests as might be approved of by the Board of Trade and for certifying meters. The draft Order promoted for Birmingham, however, omitted everything except the certifying of meters and the testing of pressure at the testing stations to be provided by the local authority. It also omitted the section of the Chelsea Order in which the undertakers are to set up and maintain proper instruments, and keep records of observations therefrom, upon all premises from which they supply electricity, such instruments being subject to inspection by the local authority. The committee also considered the question of overhead wires, and decided that they should not be allowed, and they would not be prepared to approve of any scheme in which overhead wires were contemplated. In connection with this matter, the committee discussed the proposal of the promoters of the Provisional Order to sell to the Corporation their undertaking within two years from the date of the Order being obtained, and came to the conclusion that there was nothing in the offer to induce them to recommend it to the Council. Mr. Henry Lea, technical adviser to the committee, pointed out in the course of his report the several objections which exist with regard to small central stations in the heart of the town, and suggested that the Corporation ought to work on the lines of the Deptford scheme whenever they seriously considered the question of themselves undertaking the supply of electricity. On Tuesday last the proposals of the General Purposes Committee came before the Council, and, after a long discussion, they were agreed to.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 302.)

When Prof. Henry obtained possession of the "Experimental Researches" of Faraday, as detailed in the fourteenth series of his "Experimental Researches," he was exercised in his mind to reconcile the results obtained by Faraday on the interposition of metallic screens between inducing and induced circuits with his own. Faraday had found that when the galvanometer was used as a current finder "it makes not the least difference" whether the space between the primary and secondary coils was air, sulphur, shellac, or such conducting bodies as copper and other non-magnetic metals. On the other hand, Prof. Henry found that a shock from a secondary coil which would paralyse the arms was so much reduced by the interposition of a metallic plate as hardly to be sensible on the tongue. Here was evidently something to be explained, and in a long memoir (*Phil. Mag.*, Series 3, Vol. XVIII., 1841, p. 492; also *Transactions* of the American Philosophical Society, Vol. VIII., 1840) Prof. Henry examined this and other matters. He first verified Faraday's experience by attaching the ends of a secondary coil to a galvanometer and bringing up suddenly towards it a permanent magnet, or a coil traversed by a steady current. The swing of the galvanometer was found to be quite unaffected in extent by the interposition of a plate of copper. Again, in place of the copper plate, a closed metallic conductor (an endless coil) was employed, but whether the circuit of this coil was open or closed it made not the slightest difference on the galvanometer deflection.

Forty feet of copper wire, covered with silk, were wound on a short cylinder of stiff paper, and into this was inserted a hollow cylinder of sheet copper, and into this again a rod of soft iron. When the latter was rendered magnetic, by suddenly bringing in contact with its two ends the different poles of two magnets, a current was generated in the wire, but the strength of this current, as measured in the galvanometer, was the same whether the copper cylinder was present or was removed. Prof. Henry then noticed that there was one element of difference between the indications of a galvanometer and that of the magnetising spiral. If the two secondary currents at "break" and "make" of a primary were sent through a magnetising spiral and through a galvanometer, the arrangement might be such that the induced current at "make" of the primary was unable to give any sensible magnetisation to the steel needle enclosed in the spiral, but at "break" was able to magnetise it to saturation. Nevertheless, in both cases the "throw" of the galvanometer was the same. Similarly with the degree of shock felt, the galvanometer indications being alike for the inverse and direct induced current; yet that induced current gave the greatest shock which was able to produce the greatest magnetisation. The explanation of these facts became clear as soon as it was seen that the deflections of the galvanometer depended upon the whole quantity of the discharge, and must necessarily be alike for the inverse and for the direct current, but that the magnetising effect and the physiological shock depended upon the maximum value of the instantaneous discharge current, and might therefore be very different for the two induced currents. It was then evident that any actions by which this maximum value of an induced current was decreased, whilst its duration was increased and total quantity left unaltered, would result in rendering this current less easily detectable by shock or magnetisation, but make no difference in its effect on a galvanometer. Aided by this thought, he repeated Faraday's experiment with the balanced coils referred to in § 8 ("Experimental Researches," Vol. I., § 1,790 *et seq*). A galvanometer was provided having two equal wires of the same length and thickness wound on the same frame, and also a double magnetising spiral was prepared by winding two equal wires round the same piece of hollow straw. Coil No. 1, connected with a battery, was supported perpendicularly on the table, and coils Nos. 3 and 4 were placed parallel, one on each side, and each coil connected in series with one coil of the differential galvanometer and with one spiral of the magnetising helix. The two outside coils were then adjusted so that when the battery circuit was made and broken, and the current started and stopped in the middle coil, no indication was given by the galvanometer, and no magnetisation produced in a steel needle placed in the double helix. A thick zinc plate was then introduced between the primary coil and one of the secondaries, and it was found that the needle of the galvanometer still remained stationary on making and breaking the primary current, but that the steel needle in the spiral became powerfully magnetic. This indicated that the two secondary currents, whilst still equal in total quantity, had been so affected that one had a less maximum value than the other, and hence a differential magnetising action was produced. A similar effect was observed when a galvanometer and magnetising spiral were together introduced into the secondary circuit of a single primary and secondary circuit. The interposition of a metal sheet considerably reduced the magnetising power or the shock, but left the galvanometer deflection unaltered. In order to increase the number of facts, this last experiment was varied by the exchange of a soft iron needle for the hard steel needle in the magnetising coil, the metal screen being interposed in each case, and it was found that whereas the metal screen cut off almost entirely the power of the secondary current to magnetise hard steel, it could yet slightly magnetise the soft iron. A screen of cast iron, half an inch thick, however, not only neutralised the power to magnetise hard steel, but reduced the deflection of the galvanometer as well. The general explanation of the foregoing facts, as due to Henry, is as follows:—The secondary current, as we have seen, is a brief discharge, which rises very suddenly to its maximum value and then fades gradually away. The current curve of the secondary current, due to the rupture of a primary circuit, may be represented by the thick firm line in Fig. 25. If a metal screen is interposed between the primary and the secondary circuit the screen gets a similar secondary current generated in it, and this last again acts by induction to generate a tertiary current in the secondary circuit. This tertiary current consists of two portions—first, an inverse part opposite in direction to the secondary current in the screen, and, secondly, a succeeding direct current. Let the current curve of this tertiary current in the secondary circuit be represented by the fine firm line in Fig. 25. The total quantities of electricity flowing in each part of the two portions of the tertiary current are equal. The resultant effect, then, of the action of the primary current when interrupted is to cause in the secondary circuit the true secondary current, which is an unidirectional flux (thick curve), and a superimposed tertiary current, which is a bi-directional flux, its algebraic total of quantity being zero:

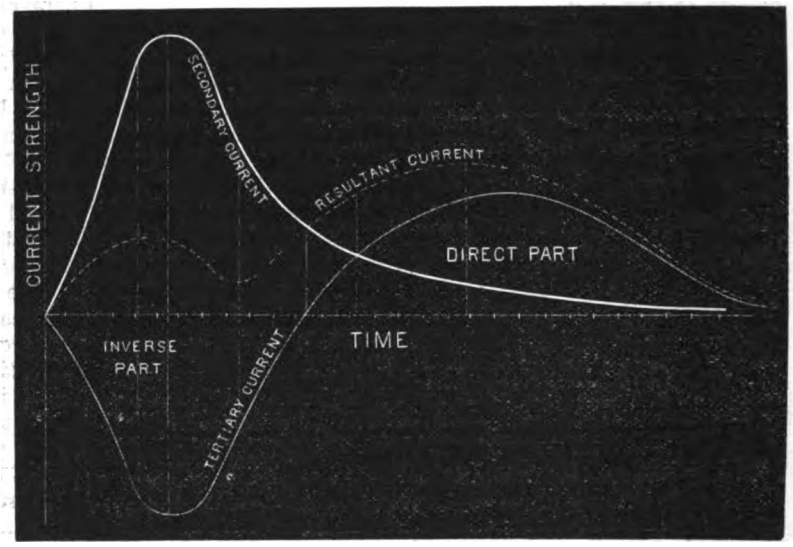

FIG. 25.

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If we add together at each instant the ordinates of the two current curves we get a resultant curve (dotted line) which represents the actual current curve in the secondary circuit. The total area (electric quantity) enclosed between the horizontal line and the dotted curve must be equal to the total area enclosed between the thick firm line and the horizontal, because we have added and subtracted equal areas; but the *maximum* ordinate of the dotted curve will be less than that of the thick firm line curve, and the *form* of the curve will be very different also. It is, then, clear that the superposition of a complete tertiary current, which is of itself but very little able to affect a galvanometer on a secondary current which gives a definite galvanometer indication, is not able to alter that galvanometer deflection, depending as it does on the total quantity of the discharge. The magnetising power and shock, however, depend upon the maximum value or suddenness with which the induced current rises to its maximum value, and this factor is very much affected by the overlaying of a secondary current by a tertiary. We see, then, that the experiences of Faraday and Henry may be completely reconciled, and that magnetic screening is a phenomenon which in this case depends upon the nature of the detecting instrument in the secondary circuit.

Reaction of a Closed Secondary Circuit on the Primary—If a Bell telephone is placed in series with a coil of many turns of fine wire wound on a hollow bobbin, and if both are placed in series with the secondary circuit of a small induction coil, the strength of the secondary current can be so adjusted that the telephone emits a low murmur or rattle. This being the case, let a solid bar of copper be introduced into the bobbin of fine wire, and it will be found that the noise of the telephone is *increased*. If a bundle of fine iron wires is substituted for the copper rod, it will, on the other hand, *reduce* the noise or stop it altogether. The explanation of this effect is to be found in the reaction which a closed secondary circuit has upon its primary in reducing the impedance of the primary. We have shown in an earlier chapter that the re-active effect of the secondary is to increase the resistance and reduce the inductance of the primary circuit, and we have deduced two formulæ given by Maxwell for the value of the equivalent resistance R′ and the equivalent inductance L′ of a primary coil of resistance R and inductance L in the presence of a secondary coil of resistance S and inductance N, the magnetic circuit having a constant resistance, and the mutual inductance being M. Hence the equivalent impedance $I m'$ of the primary coil in presence of the secondary is $\sqrt{R'^2+p^2 L'^2}$, and its isolated or intrinsic impedance is $I m$ equal to $\sqrt{R^2+p^2 L^2}$. The question is, which is the greater—$I m'$ or $I m$? To discover this, take for R′ and L′ the values given on page 337 (*Electrician*, Vol. XX.), and we have

$$R' = R + \frac{p^2 M^2 S}{S^2+p^2 N^2},$$

and

$$L' = L - \frac{p^2 M^2 N}{S^2+p^2 N^2}.$$

Forming from these the function $R'^2+p^2 L'^2$, we have

$$R'^2+p^2 L'^2 = R^2+p^2 L^2 + \left[\frac{2p^2 M^2 R S - p^4 M^2 (2 L N - M^2)}{S^2+p^2 N^2}\right]$$

or

$$(I m')^2 - (I m)^2 = \frac{2p^2 M^2 R S}{S^2+p^2 N^2} - \frac{p^4 M^2 (2 L N - M^2)}{S^2+p^2 N^2}.$$

If $S = \infty$, or the secondary circuit is open, the right-hand side of the above equation is zero, and we find that the impedance of the primary circuit is not altered by the presence of the open secondary, as of course it should not be. If S is made very small, the value of the difference of $(I m')^2$ and $(I m)^2$ continually approximates to the value $-\frac{p^4 M^2 (2 L N - M^2)}{p^2 N^2}$.

Now, $L N - M^2$ is always a positive quantity if not zero, and the other quantities in this last fraction are squares. Hence the value of this last fraction is always a positive quantity if not zero. Hence it follows that if $I m'$ is not equal to $I m$ it is always *less* than it; in other words, the presence of the closed secondary circuit always diminishes the effective impedance of the primary. We have seen *loc. cit.* that the maximum value of the primary current for the induction coil without iron and with simple periodic impressed electromotive force applied to the primary circuit is

$$I = \frac{E}{I m'},$$

or

$$\text{Maximum current} = \frac{\text{Maximum E.M.F.}}{\text{Effective impedance of primary}}.$$

Hence, since the closing of a secondary circuit around a primary reduces its impedance it must also, if the primary coil is subjected to a constant impressed electromotive force, increase the flow of current through the primary. The explanation of our experiment with the copper rod is now simple. The introduction of the copper rod into the fine wire helix is equivalent to approximating to a primary coil a closed secondary circuit. The impedance of the fine wire circuit to the alternating current from the secondary circuit of the induction coil is hence reduced; it gets more current, and the telephone is made to emit a louder sound. If, however, a core of divided fine iron wire is introduced into the fine wire helix, the result is simply to increase the impedance of that circuit, and therefore to reduce the current actuating the telephone. When considering in particular the theory of the induction transformer as applied to electric distribution we shall see the above principles have important practical bearings.

(To be continued.)

ELECTRIC METERS FOR CENTRAL STATIONS.

(Continued from page 374.)

Aron's Meter (Fig. 3).—I now come to a very interesting type of meter, the principle of which was first suggested in this country by Professors Ayrton and Perry (applause), and which has been made a practical instrument by Dr. Aron, in Germany. I have lately visited the central stations of Berlin, the largest existing on the Continent, I should think, probably, the largest in Europe. These stations are the best equipped in the way of boilers, engines, dynamos, and accessories of any low-tension system I have ever seen. It is an extremely interesting station, or number of stations. Though there are three stations already at work (and two more to come), it is only one system altogether, because all the mains are connected together all over the place. There is this defect, however, that they have hitherto used a distributing system with two instead of three wires. Of course, in every case of low-tension distribution, the three-wire system ought to be used. This fault will be remedied in the future. The two other large stations which they are now putting down are going to be supplied by the three-wire system, and I presume that they have some arrangement for connecting with their present two-wire system, though I am not sure of the details by which that is going to be accomplished. They supply at present current sufficient for a maximum of 26,000 incandescent lamps of 16 candle-power. I beg to state that I have never found in the European stations that you have to divide by two the number of lamps which are stated to be used on the circuit in order to get the true number (laughter). I am utterly unaware of the reason, logical or moral, by which that course is supported in this country. But when I know a station using 16-candle lamps, and when I know of their counting the number of lamps which they say are supplied by exactly doubling the number which are actually in use, for the life of me I cannot understand what logic or morality there is in it (laughter.) It may be that they confess that their 16-candle lamps only give 8-candle power; but that is not the case, because they are speaking of the total number of 16-candle lamps they are able to supply. But there is a great tendency too, here in London, among a limited number to express a wish that we should have 8 candle-power lamps as a general rule instead of 16 candle-power lamps. All I can say against that is that at the present moment the so-called 16 candle-power lamps which we see in London are generally not more than 8 candles, and I never heard much satisfaction expressed with that (hear, hear). In the second place, it is the universal experience in hundreds of central stations in different parts of the world that the 16 candle-power is the practical standard with full pressure, and I do not see what ground we have to say that the 8-candle lamp has been found in practical experience to be a more suitable standard for ordinary consumption (hear, hear). I should be inclined to say let us rather go to 20 candles. As a general rule,

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of course, there are places where 8-candle lamps can be used, and it is very desirable to have the means of putting in 8-candle lamps when you want them.

Now I return to the Berlin central stations. In addition to those 16 candle-power lamps of which I have spoken, the station of the Allgemeine Elektricitäts Gesellschaft also lights up the Unter den Linden with 108 arc lamps of 15 amperes, and the Leipziger-strasse with 36 arc lamps. The former is the finest piece of street lighting ever accomplished, not excepting the Avenue de l'Opera in Paris in the old days of Jablochkoff, which was very brilliant indeed.

All the incandescent lamps are charged for by meter, and the Aron meter is always used. Originally it consisted of an ordinary clock, with a permanent magnet for the bob of the pendulum; below this a coil of wire is fixed with its axis vertical. The current to be measured passes through this and repels the magnetic pole, thus diminishing the influence of gravity on the pendulum, and causing the clock to lose time. The loss of time in any period, as compared with a good, uninfluenced clock, shows the number of units of electricity which have passed through the instrument. It takes a long time to test such an instrument over its whole range, and I have not been able to obtain any tests. The chief inconvenience of the instrument in its old form was that a clock could not be depended upon for accuracy more than about half a minute a week. One minute a week would be the smallest registerable quantity. Suppose this means one lamp-hour, then the maximum loss of the clock in the week being 12 hours, the instrument could not register more than $12 \times 60 = 720$ lamp-hours per week. Another inconvenience was having to wind up so many clocks every week. The former defect has been got over by mounting two clocks on the same frame-work, one in its normal condition, the other governed by the current. The two trains of wheels are connected by a differential gear with a third train of wheels with dials and pointers like a gas-meter. This increases the range of the instrument, so as to be practical. Of course, this improvement diminishes the accuracy of the instrument, and has been found to do so in practice (1) by introducing more work for the clocks to do, and (2) by having to deal with the ordinary errors of two clocks; and every clockmaker knows that two pendulum clocks, mounted on the same frame, affect each other's going, and introduce errors. The principle of this meter is very beautiful, and in the Berlin central stations the authorities speak in very high terms of its value. Complaints from customers do come in, but in these cases the meters are tested, and found to work quite well. Its range is greater than for any other meter, being about 100-fold, I believe. I have two specimens of this meter, which have been kindly supplied to me by the General Electric Supply Company. One is of the modern type, with two clocks, working quite independently, with the two pendulums. In front you will see the counting mechanism, which is worked by differential gearing between the two clock trains underneath. We notice that the bob of the pendulum under one of them is a permanent magnet. Below the bob of the pendulum is a coil of wire through which the current passes. This repels the magnet and diminishes the effective gravity, and then the counting mechanism allows you to read it off quite easily. There is another type—that is the type for alternating currents—in which a coil is moving inside another coil, and the effect is of the same character.

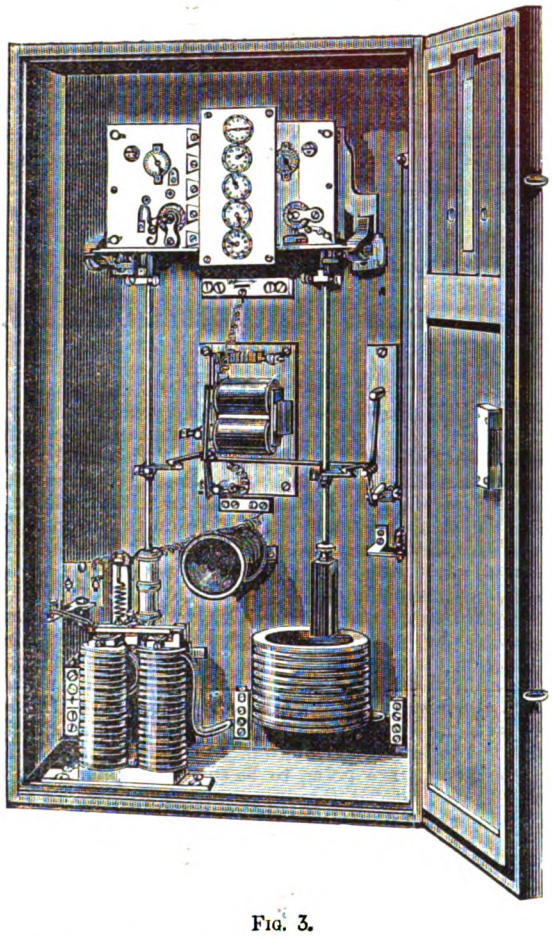

Fig. 3.

This meter has been altered, to adapt it for registering alternating currents, by replacing the permanent magnets by coils or electro-magnets. In the central station at Rome, which is in many points the finest and best designed station for alternating currents which I have yet seen, it is intended to test these meters. But I can say nothing about their accuracy. I will only point out that in this case the retarding influence would vary as the square of the current, whereas, with the permanent magnet, it would vary as the current. This does not lead us to hope for the same satisfaction as is undoubtedly given by the type for continuous currents.

Lowrie-Hall Meter (Fig. 4).—I will now say a few words about a meter specially designed for alternating currents, which resembles the Edison meter more than any other. This is the Lowrie-Hall meter. A battery—preferably a secondary battery—is placed on the secondary circuit of a transformer. An electrolytic cell is also placed in the circuit. Now there is no complete circuit through the battery and electrolytic cell except when the lamps are in circuit, and it is only then that electro-chemical decomposition can take place. The alternating current does not transfer metal from one plate to another. The whole effect in this way is produced by the battery, which acts as if the alternating current did not exist. Allow me to point out this by means of a diagram (Fig. 5). Suppose P to be the primary wire of a transformer and S the secondary, L being the lamp circuit. In the Lowrie-Hall meter a secondary battery, B, is put in series with the secondary coil; also an electrolytic cell, C, is inserted. Now, the alternating current which is passing through that circuit has no effect in decomposing the liquid, and, therefore, any effect is altogether due to this secondary battery. What is the quantity of current the electrolytic cell will measure? The quantity of continuous current which is flowing through the circuit depends upon the resistance of these lamps, and is proportional to the conductivity of the lamps, that is to the number of lamps that are on the circuit. It is an extremely

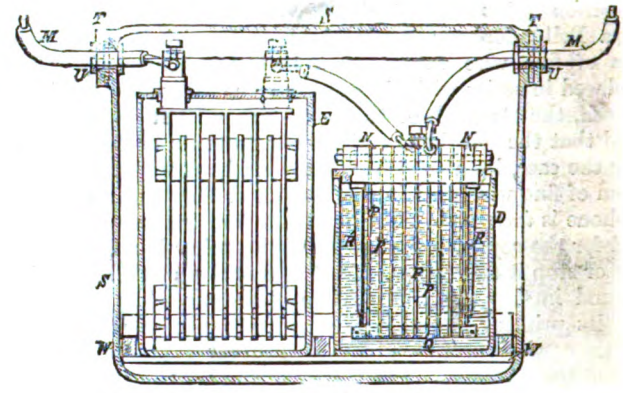

Fig. 4

M Mains. W Wood packing.
S Case. P Plates.
E Secondary battery. T Terminals.
D Depositing cell

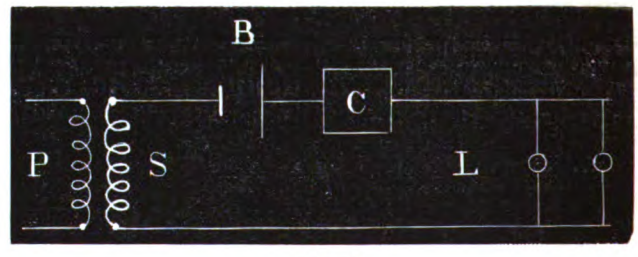

Fig. 5.

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beautiful idea. Thus the total number of lamp-hours, or Board of Trade units, is measured by the quantity of metal lost by one plate or gained by the other. One is inclined to ask how long the battery will stand the alternating current, and whether there is much trouble in charging and replacing the secondary batteries. On those points I cannot speak personally, but I am informed that these meters have been successfully at work at Eastbourne for more than a year. As a further proof of the value which has been attached to the performance of this meter, I may mention that in the West Brompton Station of the House-to-House Electric Company the same meter is going to be used, owing to the successful experiments which have been made at Eastbourne.

Schallenberger Meter (Fig. 6).—A very practical form of meter has lately been brought out by Mr. Schallenberger, electrician to

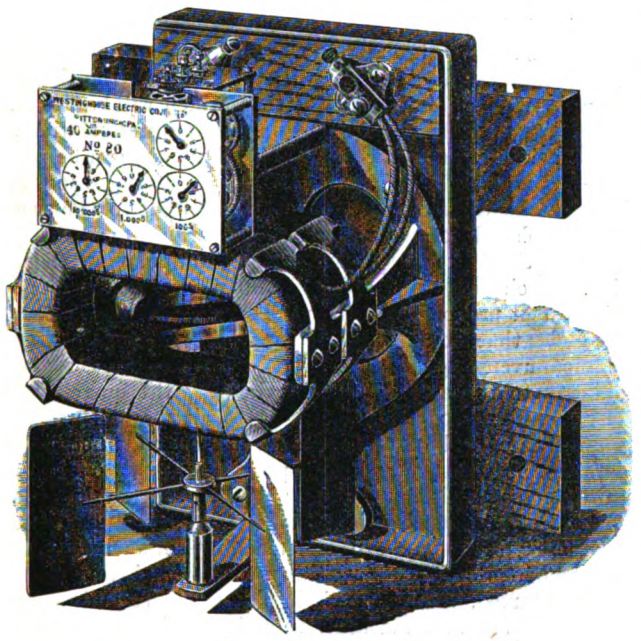

Fig. 6.

the Westinghouse Company at Pittsburg, an extremely ingenious and accomplished electrician. It also is intended for use only with alternating currents. This is not the place to go into a scientific

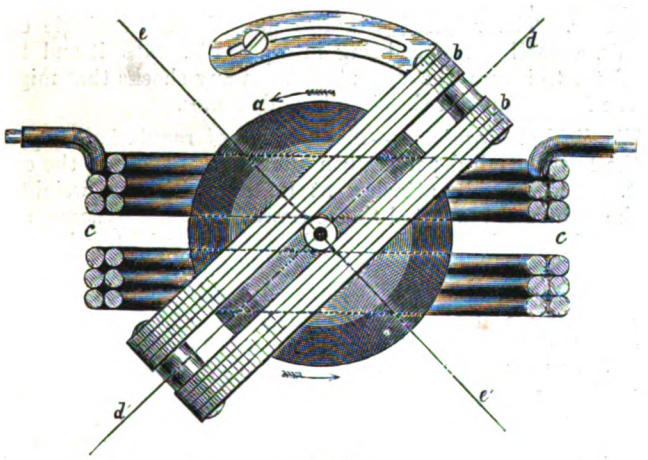

Fig. 7.

a. Flat ring of soft wrought iron.
b b. Copper plates, placed so as to surround the disc closely without touching it.
c c. Coil surrounding the whole.

examination of the theory of its action. I will try to explain it in popular language. I have here a diagram (Fig. 7) which shows in a sketchy way the general principle of it extremely well. Mr. Schallenberger is sending me one of these meters, but I am sorry to say that it has not arrived in time for me to be able to show you the meter itself. I will show you on the screen a photograph of it by the aid of the lantern presently, which will make it almost as distinctly visible as if I had the meter on the table. In the diagram we are looking downwards upon it. The meter consists essentially, in the first place, of a circular iron disc upon a vertical axis. This disc is, however, free to move, and it is connected with a train of counting mechanism. It also has upon the same axis fans to introduce air pressure to prevent the instrument from going ahead too fast. Two diameters of the circular disc are chosen inclined to each other at an agle of 45deg., and coils of wire are wound around on those two diameters. One coil of wire is short-circuited in itself, and is not connected in circuit. The other coil of wire, inclined at an angle of 45deg. to the first, carries the current which is to be integrated.

Now let me show you what action takes place. When a current is passing through this main circuit it induces a secondary current in the circuit which is inclined 45deg. to it, and this induced current attains a maximum a quarter of a period later than the maximum in the principal circuit. What then happens? First, the principal circuit attains a maximum and magnetises the iron disc. When the principal circuit falls to zero the secondary circuit attains its maximum, and tends to move the pole which has been created in the iron in a certain direction. When the principal current is going in the opposite direction it magnetises the disc in the opposite way.

It also induces a secondary current in the opposite direction; therefore the rotation of the disc will be in the same direction as before.

Thus, whether the current in the principal circuit is positive or negative the influence of the secondary circuit upon the pole induced in the iron is always such as to turn it in the same direction, and you have continuous rotation of the iron disc due to an alternating current in the principal circuit of the instrument (applause). This instrument acquires additional interest from the fact that it was invented and almost completed before the Ferraris or the Tesla motor (an instrument which was founded upon the same principle) was invented.

I think that one of the few objections which can be raised to this meter is that its indications vary with the speed of reversals of the alternating current; but every meter which is founded on magnetic action must have that defect. It is generally said that in practice the variation from this cause will not be more than one or two per cent. There is no doubt the meter remains a beautiful practical instrument, which is doing splendid work in the United States.

Forbes's Windmill Meter (Fig. 8.)—Some years ago, when I first realised the value of the invention of Messrs. Gaulard and Gibbs for distributing high-tension currents in the main and delivering it as low tension in the houses, I felt that one difficulty in the

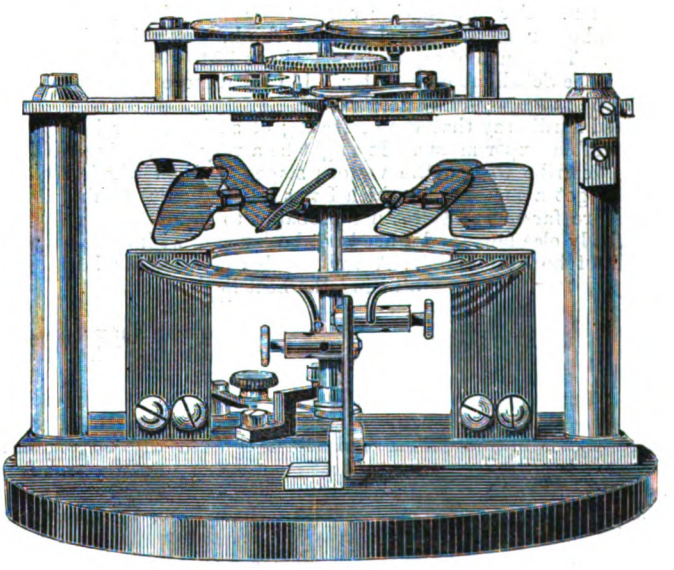

Fig. 8.

way of adopting it was the want of a meter for alternating currents. Such a thing did not exist, and I felt certain that the public would never be satisfied with a meter whose indications depended on the speed of reversals. In this I seem to have been a little in error; I believe the objection is not so serious as I then thought. It seemed to me that the heating quality of the currents was the only one which would succeed, and would be equally applicable to continuous aud alternating currents. I was fortunate enough to have the kind assistance of Mr. A. Stroh for perfecting the details of the instrument which I then set to work to make; and it is to Mr. Stroh's ingenuity and assistance in working out the details of the instrument that I almost entirely owe such success as the instru-

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ment has attained. I cannot express too strongly the feeling of obligation which I am under to Mr. Stroh for his continuous assistance in developing this meter (applause). You may call this a "Windmill meter." I have several specimens on the table. The current is passing through one of them, which is now, as you see, rotating. The conductor in the meter carries the current, and is just underneath a kind of windmill. The conductor becomes heated, and sets up convection currents in the air; these convection currents turn the windmill, and the number of revolutions of this windmill are indicated by mechanism, much like those other mechanical meters which I have shown, and the total velocity is proportional to the current.

The windmill which I use is made of a horizontal mica disc, with mica vanes round the edge, inclined at 45deg., attached to it by small pieces of pith. It has a hole in the centre, in which is fitted a thin paper cone, which has at its apex an aluminium cone, supporting a steel pinion with a ruby cup in its centre. This cup rests on a needle point, and the pinion works into the train of wheels which does the counting.

When this meter was perfected it seemed that the English demand was not great, and it was best to modify it to suit the American market. I went to America to find out exactly what was wanted, and altered the instrument accordingly. The chief objection raised to it was the difficulty of mailing it, and a fear that it was too delicate. Consequently I strengthened some of the parts, reduced the sharpness of the needle point, and provided a metallic case in place of a glass shade. A considerable number have been sent across the Atlantic in both directions without any injury by the ordinary channels. On arrival all that has to be done is to loosen a screw, so as to free the windmill, and let it play upon the needle point. The electric resistance of the conductor had also been objected to. That was a serious objection to the instrument as it was first brought out, though I did not notice it until I began actually to have it in practice on lamp circuits. This I was able to correct by altering the form of the conductor in which the heat is produced. Its resistance is now $\frac{1}{100}$th of an ohm, and Mr. Schallenberger, after testing at Pittsburg a batch which were sent direct from Mr. Grove's workshop, without any adjustment, wrote to me, saying that they are quite accurate, and that the fall of voltage, due to resistance, is quite low enough for practical purposes, and that they were put to work on the regular commercial circuits in Pittsburg. Mr. Westinghouse has acquired the rights for America, and is now manufacturing them at Pittsburg. It is the only meter which he supplies for motors and continuous currents, and it also works equally well with alternating currents of any speed of alternation. For alternating currents he has hitherto used the Schallenberger meter, and I should think, probably, will do so largely. The range of my meter is about 12 to 15-fold, about the same as the Schallenberger meter. If I used more delicate wheelwork, the range would be greater.

I need hardly say that the perfecting of such a meter has led to innumerable experiments. It might be a very interesting task to me to describe to you the various stages through which I went before I got a meter with which I was satisfied; but I think these details are far more interesting probably to myself than they are to anybody else here, and I need not bother you with these varying periods of hope and trial. A vast number of attempts have been made at other means of utilising the heat in the best way. I will not describe these various methods, which did not generally arrive at much success, but I feel that I would not be doing my audience justice if I did not show them one other type which I have constructed, which is very simple and effective, but which has one slight defect—viz., that it is not easy to manufacture in numbers, all exactly alike. This meter consists of a wire conductor of very low resistance indeed. This conductor is covered with cotton, and is kept moistened by having the cotton dipping into a vessel full of alcohol. The heat generated in the copper wire evaporates the alcohol on the cotton, and deposits it in a tube, in which the quantity of alcohol condensed may be measured. This is very accurate over a considerable range; but it is very difficult to make a large number of them to read the same. This instrument has not been used on commercial circuits, and therefore in accordance with the dictum with which I began this address, I ought not to have alluded to it; but I felt that I ought to say this for other reasons.

Since the beginning of September, 1887, when I first exhibited the mill-wheel meter, an enormous number of patents for meters have been taken out; indeed, the weekly patent return almost invariably shows a new meter taken out every week. But I think I have described (at any rate I have done my best to find out and describe) to you all those which have as yet proved themselves to be of practical value. Each of the meters I have described has its merits, and all are doing good work in central station distribution in some part of the world or other (loud applause).

An interesting discussion followed, which will be given in our next issue.

THE WEST BROMPTON STATION OF THE HOUSE-TO-HOUSE COMPANY.

(Concluded from page 368.)

Switch and Test Room.—All the electrical connections converge in the switch and test room, and the man in charge there can control by signals the starting or stopping of any set of plant and the connecting or disconnecting of any circuit. The high-tension terminals of the dynamos are hidden in the frame, and the wires are taken by a covered main trench to the switch room. This trench runs all around the switch room behind a screen. The switch blocks are mounted on this screen, and the connections made behind, so that not a single wire or connection is in the room.

The leads are first brought to a double-pole cut out, arranged so that a fuse can be replaced without stopping the dynamo; and by a system of four break switches, which will be explained later on, any dynamo can be put in communication with any circuit or circuits, or the whole of the dynamos can be put in parallel circuit. Besides these mains conveying the entire E.M.F. of the dynamo, a small wire is brought to the switch-room, and placed across one coil of the armature; this is for measuring the voltage, synchronising, and for regulating the E.M.F. Each coil being exactly similar, the measure of one coil is a direct proportion of the whole; this device obviates any inaccuracies that would occur in measuring from a converter. A simple current register is also included on the switch board to indicate to the attendant approximately the current given out by each dynamo, and is arranged to ring a bell when the maximum safe load of any dynamo is reached, when he can either put in another machine parallel or put one of the circuits on some lighter working dynamo, if working independently. The synchronising is effected through the one-coil circuit; for instance, if one machine shows by the indicator that the load is approaching the normal, and another plant is started, a small switch places the second machine parallel with the first machine, though one lamp only, placed on the synchronising board. When the phases of the two dynamos correspond the lamp is steady and bright, but not until then. The second machine is then instantly put in parallel with the first by the insertion of one main switch, and at once takes half the load. Any inclination of one plant to get out of pulse with the other throws more of the work on the faster engine, and reduces its speed, so that one plant controls the other. The regulation is also done from the single coil circuit, a small converter being interposed between it and the regulator to insure the attendant from any shocks that might accrue from a fault in the circuits or dynamos.

The E.M.F. Regulator.—The method of regulation adopted in the Lowrie-Hall depends upon the thermal effect of the current. A wire rigidly attached at its extremities and weighted at the centre is connected to the terminals of the dynamo, and the sag formed in the wire by the central weight, when the wire is expanded by the heat generated, gives an efficient and sensitive motion which is well adapted to the purpose in view. For an example, if the wire be 60in. long, and its expansion is one-quarter of an inch, then the sag of the wire amounts to 2·74in., which is equivalent to a gear multiplying eleven times, with none of the friction or other cause of loss of sensibility appertaining thereto.

Fig. 2 illustrates the complete instrument. Fig. 3 is a diagram of the connections.

Across the terminals of the converter M, two fine wires, E and F, supported between the fixed points, Z, Y, and Z^1, Y^1, whose normal positions when cold are shown by the dotted lines, are connected; the two wires being in series with one another, and connected by the wire, Y, Y^1. The field-magnets of the dynamo A are excited by the exciter B. Across the fields of this exciter a shunt of varying resistance is placed, connected by the wires, d, d^1; this shunt resistance is formed by two metal plates dipping in the solution in the electrolytic cell D, and its resistance is altered by the raising and lowering of the plates into the solution, which is accomplished automatically by the passage of a current through either the top coil C, which

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lowers them, or the bottom coil C^1, which raises them by their attraction for a movable iron core inside the coils. This core is attached to the plates by a cord passing over a pulley, d^2.

To the centre of the wire E a cord is attached, the other end of which is fixed to the arm e of the rocking arm e, e^1; this arm is pivoted at e^2 on a fixed support. If the E.M.F. of the dynamo rises too high, the sag becomes greater, and the arm e is pulled down by the weight e^3, and so makes contact on the table c; if, however, the E.M.F. falls, the wire pulls the arm e up, so causing the other arm e^1 to make contact with the table c^1. To the centre of the wire F the cord f is attached, which raises or lowers the arm f^1, pivoted at its end, off or on to the table f^3. This table, f^3, is connected to one pole of the exciter, and the pivot of the arm f^1 is connected by the wire f^2 to the pivot of the rocking arm e^2; the able c is connected to the top coil C, and the table c^1 to the bottom coil C^1, the other ends of these two coils being jointly connected to the other pole of the exciter.

If now the E.M.F. of the dynamo rises too high, the arm e falls, so making contact with the table c; the E.M.F. of the exciter is therefore right across the coil C, one side being in metallic connection, and the other being connected through the table f^3, up the arm f^1, through the wire f^2, to arm e, so passing through the table c, connected with the coil C. This coil coming into action pulls the core up and so lowers the plates into the solution, which therefore lowers the resistance of the shunt, so causing a smaller current to pass round the fields of the exciter, and consequently weakening the field of the dynamo A, so lowering its E.M.F. These coils are wound with fine wire, and are of high resistance.

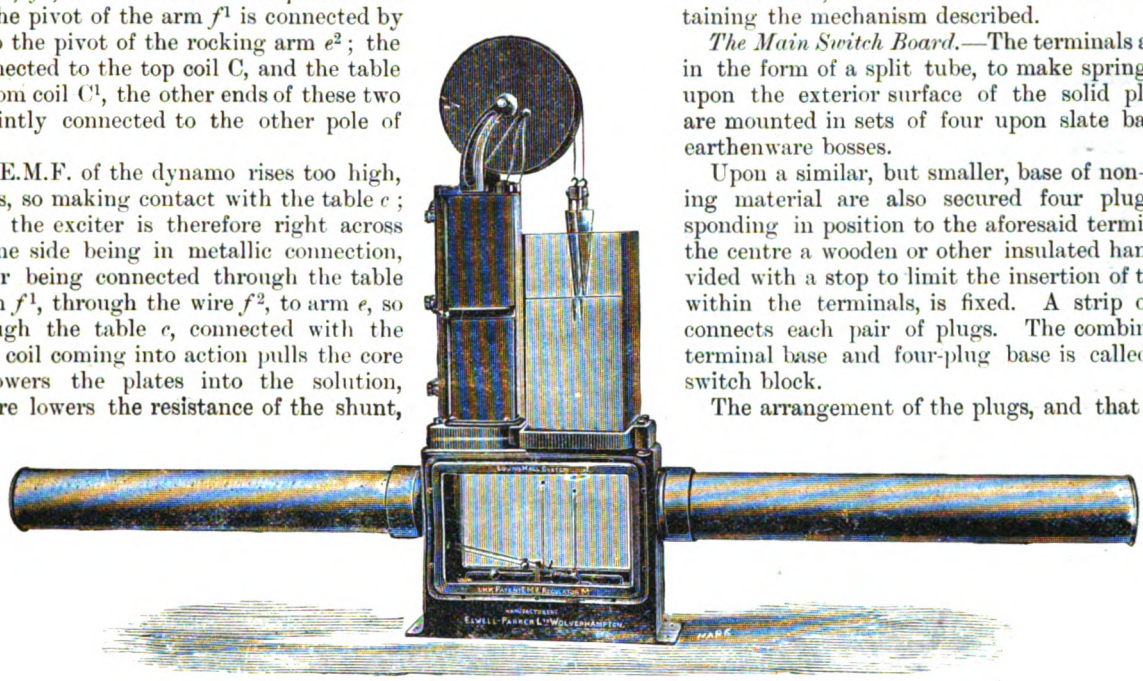

FIG. 2.—THE LOWRIE-HALL POTENTIAL REGULATOR.

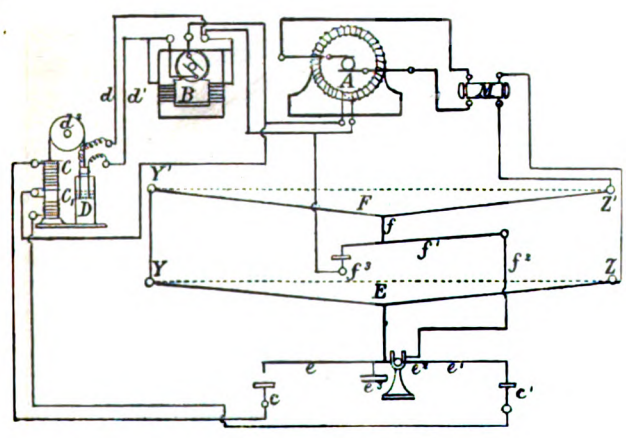

FIG. 3.

If, however, the E.M.F. is too low, the arm e^1 touches the table c^1, so shunting the current through the coil c^1, which coming into action raises the plates out of the solution, and consequently the resistance of the shunt, so that more current passes from the exciter round the fields of the dynamo A, whose E.M.F. therefore rises. The arm f^1 is put in to cut out the action of the regulator in the event of the wire E breaking, for that wire by breaking would stop the passage of the current through the wire F, so making the latter contract and pull up the arm f^1, so breaking its connection with the table f^3. If no provision is made for this accident the arm e, by making permanent contact with the table c, would lower the E.M.F. of the dynamo as far as the shunt would allow. In the shunt resistance the two plates which are fixed to an insulating piece dip into the solution contained in the glass cell, and are supported by two chains, which pass over the two ebonite wheels. On a smaller pulley a chain is fixed, supporting the iron core, which moves up or down in the coils; the speed of the motion of the plates is increased or decreased by the ratio of the diameters of the pulleys. The coils are wound upon a brass tube, which is filled with glycerine to act as a dashpot, the core acting as a plunger itself.

In the actual instrument (Fig. 2) the wires are stretched in a brass tube, in the centre of which is a box containing the mechanism described.

The Main Switch Board.—The terminals are made in the form of a split tube, to make spring contact upon the exterior surface of the solid plugs, and are mounted in sets of four upon slate bases with earthenware bosses.

Upon a similar, but smaller, base of non-conducting material are also secured four plugs corresponding in position to the aforesaid terminals. In the centre a wooden or other insulated handle, provided with a stop to limit the insertion of the plugs within the terminals, is fixed. A strip of copper connects each pair of plugs. The combined four-terminal base and four-plug base is called a unit switch block.

The arrangement of the plugs, and that of their corresponding terminals, is that of a rectangle, nearly square in dimensions. This is to prevent the plug base being inserted wrongly in the terminal base, that is to say, to make vertical connections (for example) instead of horizontal ones.

Upon one side of each square is connected a generator, and upon a horizontal line with each of these are the terminals of the outer circuits.

The arrangement is such that one pole of a dynamo machine is connected to one terminal of a unit switch block, while the other pole is connected to the diagonally-placed terminal of the same switch block. Similarly, each pole of the outer circuit switches is electrically connected to the remaining two terminals of the same block.

Provision is made by grooves at the back of each unit switch-block to extend all the electrical connections to the adjoining unit blocks in the same symmetrical manner. For example, when four unit blocks are combined together as a square, with connections from two dynamos on one side, and connections to two working circuits at right angles thereto, the whole of the current from the two generators can be conducted into one of the working circuits; or the current from one machine led into one circuit while the other machine is supplying the other circuit; or one circuit is fed by both machines while the other circuit draws its supply from one machine only; or, finally, both circuits may be fed by both generators, according to the number and arrangement of the plug bases engaged with their respective terminal bases.

Thus any number of generators and circuits can be electrically connected by adding the requisite number of unit switch blocks in the manner indicated. For synchonising previous to connecting two dynamos in parallel an incandescent or glow lamp is provided beside the unit switch blocks.

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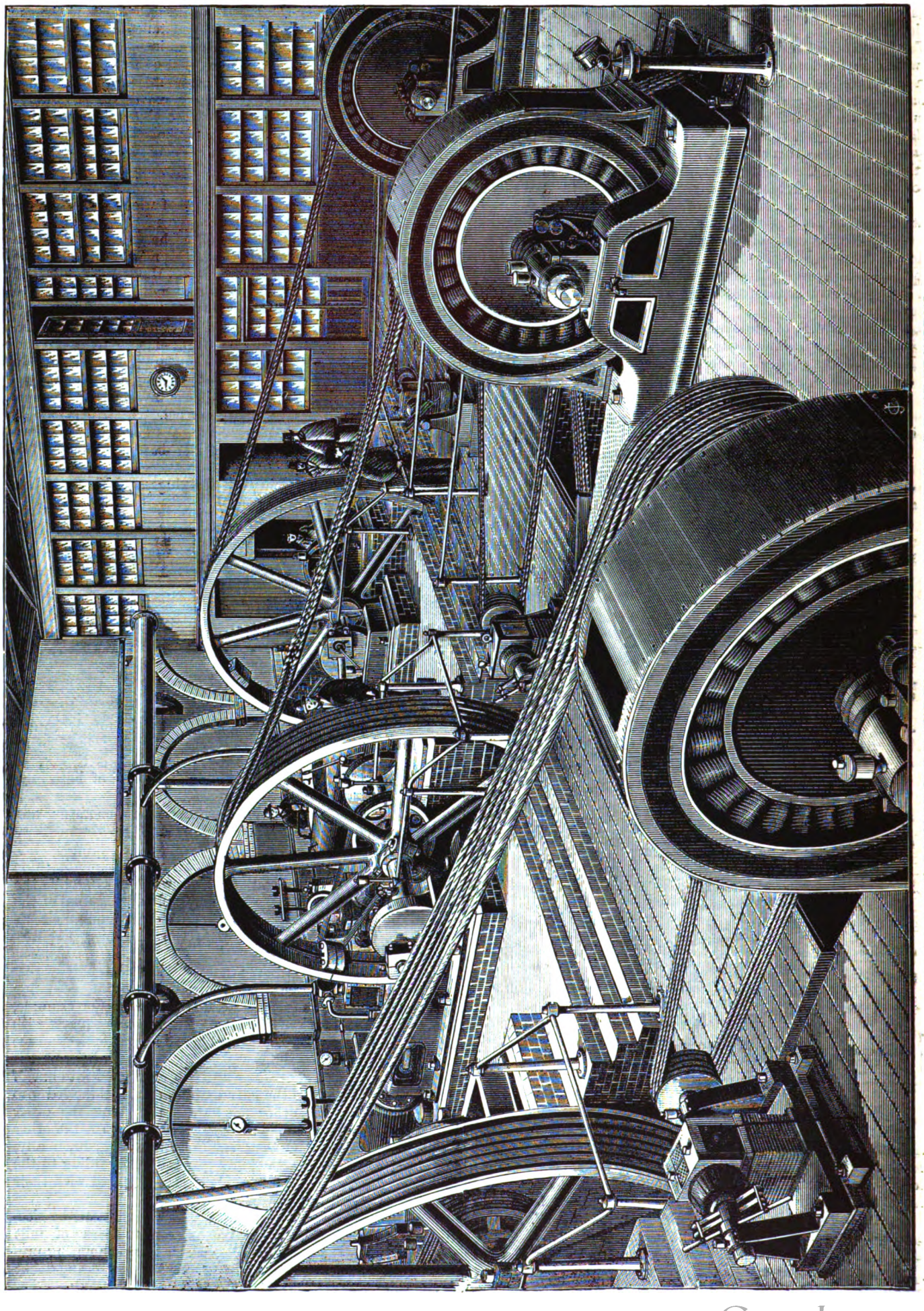

PART OF ENGINE ROOM OF THE HOUSE-TO-HOUSE COMPANY'S STATION AT WEST BROMPTON

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Distributing Mains and Method of Testing.—After leaving the switch board, the different circuits are composed of very highly-insulated conductors, encased in lead and braided outside, all joints in which are made by a special machine. These mains will be drawn into cast-iron pipes, specially designed to overcome the objections of Local Authorities to disturbing the road after the pipes are once laid down. The road boxes, junction boxes, distributing boxes, &c., used in this system are all made interchangeable to any size pipe, either main or branch. A considerable length of piping has been laid down, but the conductors are not drawn in.

An ingenious method has been devised for testing the insulation while the current is on. The apparatus consists of a small box containing a vacuum tube, one of the electrodes of which is connected to earth, while the opposite electrode is connected by its terminal to a pole of the conductor under test. The box is provided with an orifice through which the tube may be observed, and the interior of the box is blackened. If the insulation of that portion of the conductor under test is bad, the characteristic glow of the vacuum tube when current is passing between the poles is wanting, because earth connection is made at the extremities of the testing circuit. On the other hand, if the insulation is good the glow of the tube is present, because current is discharging through the vacuum tube to earth. The glow is vivid or otherwise in proportion to the quality of the insulation and potential of the current, and may be compared with a standard vacuum tube or other light-giving means, and measured by a photometer.

Each pole of the insulated conductor is tested in the manner indicated above, as it is to be noted that if a fault exists upon another portion of the conductor than that under test (the latter being well insulated) the glow is present; but on the connection being shifted to the opposite pole—on the faulty side of the cable—the discharge through the tube is diminished or ceases in the manner before stated. Any section of a conducting cable may be tested, and a fault localised in the manner described. The use of this continuous recorder entirely removes the necessity of stopping any circuit unless a fault is known to exist, and the risk of inconvenience by stoppage of the light is reduced to a minimum.

The Lowrie-Hall transformer was described in our issue of February 10th, 1888, p. 343. The Lowrie-Hall meter is described and illustrated in the present issue by Prof. Forbes in his recent lecture before the Society of Arts.

UNDERGROUND MAINS.

BOARD OF TRADE CIRCULAR.

We are indebted to the Secretary of the Board of Trade for the following copy of a circular which has been addressed to various local authorities in whose districts roads have been broken up for the purpose of laying mains for electric lighting purposes:—

(Copy.)

"Board of Trade (Railway Department), London, S.W.
"29th January, 1889.

"SIR: I am desired by the Board of Trade to state, for the information of the Vestry, that their attention has been called to the fact that certain streets in the parish of ——— have been, and are being, broken up with a view to the laying of mains for the supply of electricity by persons having no statutory powers under the Electric Lighting Acts, 1882 and 1888.

"The Board of Trade have been advised that no member of the public (and a company not possessing statutory powers would be in the position of a member of the public) can either with or without the 'assent of the local authorities interfere with public highways in such a way as to cause obstruction to the public, even though such obstruction were limited to the time during which they were executing their work.'

'It is in the opinion of the Board of Trade very undesirable that mains for the supply of electricity should be laid down in any street, being a public highway, by persons possessing no Parliamentary powers.

"The applications for statutory powers now before the Board of Trade show that there is considerable competition in the metropolis for the privilege of supplying electricity, and the difficulty of dealing with these applications in the general interest of the public will be materially increased if individuals or companies have laid mains without statutory powers and consequently without the obligations which the Legislature has imposed for the protection of the interests of the public.

"It must also be remembered that the financial interests of electric undertakings which occupy streets with their mains, and supply electricity to the public without statutory power, are by no means secured in the same way and to the same extent as if they possessed those powers, since, in the first place, their works run the risk of being stopped by the direction of a court of law at the instance either of some public authority or of any one who may at any time now or hereafter feel himself aggrieved; and since, in the next place, they do not possess the remedies for enforcing against their customers their charges which the Legislature has given to those who obtain statutory powers.

"The status of applicants to the Board of Trade, and through them to Parliament, should be such as to ensure perfect equality to all, and there is danger that this might not be the case if any persons either being or about to be applicants for statutory powers were in the actual occupation of streets.

"It has become, therefore, necessary to consider the action which may have to be taken in view of the facts above referred to, and I am desired to request the early observations of the Vestry upon the points mentioned.—I am, sir, your obedient servant, (Signed) "HENRY G. CALCRAFT."

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, February 8th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Flexible Wheel-Bases of Railway Rolling Stock." By G. D. TWINEBERROW, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Electrostatic Measurement." By Sir WILLIAM THOMSON, F.R.S.

SATURDAY, February 9th.

PHYSICAL SOCIETY.

3 p.m. Annual General Meeting. "Physico-Geometrical Models." By Prof. A. S. HERSCHEL.

MONDAY, February 11th.

LONDON INSTITUTION.

5 p.m. "Some Curiosities of Magnetism." By SHELFORD BIDWELL, F.R.S.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture III. 1.—"Wood Engraving." By W. J. LINTON.

TUESDAY, February 12th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "Some Canal, River and other Works in France, Belgium and Germany." By L. F. VERNON HARCOURT, M.A., M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Salt: its Production and Consumption at Home and Abroad." By PETER LUND SIMMONDS, F.L.S.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture, "Africa and the Horrors of Slavery, by One Who Knows What He is Saying." By Commander CAMERON, C.B., R.N.

WEDNESDAY, February 13th.

CITY AND GUILDS OF LONDON INSTITUTE OLD STUDENTS' ASSOCIATION.

7:45 p.m. Meeting at the Central Institution, Exhibition-road. Paper to be read, "Petroleum," by JUSTUS ECK (Member).

THURSDAY, February 14th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Metamorphoses of Minerals." By Prof. J. W. JUDD, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting, Conclusion of Discussion on "The Insulation Resistance of Electric Lighting Circuits." By Prof. A. JAMIESON (Member), F.R.S.E.
"On Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits." By A. E. KENNELLY (Associate.)

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The Electrician.

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All letters intended for insertion in "The Electrician," or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
Within Postal Union	6 6	12 6	24 0
„ Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

TO ADVERTISERS.

"The Electrician" offers exceptional advantages to Advertisers. **It has the largest circulation of any English Electrical paper, and circulates all over the World.**

Particulars relating to Advertisements will be promptly forwarded on application to this office.

Trade Advertisements *intended for the current issue must be handed in not later than First Post on Thursday morning.*

Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

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"The Electrician" Printing and Publishing Company (Limited) *beg to inform Electricians and Electric Light Engineers that they make a specialty of Technical Printing, and have a Staff thoroughly acquainted with Electro-Technology. They can, therefore, promise Accuracy and Despatch in the Printing of Electrical Catalogues and Electro-Technical Literature generally.*

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Royal 8vo. Cloth Boards, 3s. 6d., post free 4s. (Great Britain).

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes	387	Books Received	409
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued	392	American Notes	410
Electric Meters for Central Stations. Illustrated. Continued	393	Notes from Germany	411
The West Brompton Station of the House-to-House Electric Company. Illustrated. Concluded	396	Scandinavian Notes	412
Underground Mains.—Board of Trade Circular	399	Correspondence—	
Meetings of Scientific Societies.	399	Inductive Influence between Distant Circuits.—Oliver Heaviside	412
The Kensington Vestry and the Electric Light	400	Light Without Heat.—A. B. Worth	412
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued	401	Constant Current Regulation. Douglas C. Bate	412
"Notes on the Design of Electric Motors."—*Discussion.* Illustrated	403	Alkaline Accumulators.—H. J. Coates	413
"Modern Views of Electricity"	407	Hookham's Electricity Meter. George Hookham	413
A "Universal Galvanometer." By Dr. D'Arsonval. Illus.	408	Globular Lightning.—Ernst Fahrig	413
On the Electrification of Metallic Plates by Illumination with the Electric Light. By W. Hallwachs	409	The Lighting of the City of London	413
Legal Intelligence—		Electric Lighting in Kensington	414
In re Gaulard and Gibbs' Patent.—Appeal.	409	Patent Record	416
Watt *v.* Maxim-Weston Electric Light Company	409	Companies' Meetings, &c.—	
		Cuba Submarine Telegraph Company (Limited)	416
		German Union Telegraph and Trust Company (Limited)	417
		Anglo-American Telegraph Company (Limited)	417
		Taunton Electric Lighting Company (Limited)	419
		The India-Rubber, Gutta-Percha and Telegraph Works Company (Limited)	419
		City Notes, &c.	419
		Companies' Share List	420

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THE KENSINGTON VESTRY AND THE ELECTRIC LIGHT.

As the parish of St. Mary Abbotts, Kensington, comprises one of the wealthiest residential districts of the metropolis, and is consequently one of the most promising areas for the introduction of the electric light, it is not surprising that it should have occupied a prominent position in the minds of nearly every electricity supply company in London, or that the parish itself is very much alive to the value of the patronage which it has to bestow. It remains to be seen whether any of the rival companies will push their claims to the verge of self-destruction by conceding too much; but on the part of the parish authorities it is plain to be seen that they are not disposed to let the applicants concede too little. Evidence of this will be found abundantly in the elaborate Report of the Electric Lighting Committee appointed by the Vestry, an abstract of which we publish in this week's issue. The Report itself is of great interest just now, partly because of the importance of the district to which it relates, partly because of its being almost the first of its kind yet published, but partly also because of the evident care and ability which have been devoted to its consideration. The Kensington Vestry have lost no time in adopting the Committee's Report unanimously; and it will probably be taken as a model and a precedent for other

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vestries to copy and to follow. This being the case, a great responsibility rests upon the electric lighting undertakers for the Kensington district to see not only that their own interests are equitably dealt with, but that those of the trade generally may not be handicapped by concessions which in other less favoured localities may be utterly inadmissible.

We shall, in fact, be surprised and disappointed if certain of the conditions proposed in the report are accepted by any of the competing companies; but at the same time we have no serious fault to find with the committee for endeavouring to make a good bargain where the opportunity, as in this case, is so tempting. And in many respects the Report is characterised by a fairness and reasonableness which are highly praiseworthy. Beginning by careful inquiry into the financial position of the six applicants for Provisional Orders in the district, the Committee have decided that none of the companies shall be excluded on that ground, but that on grounds of expediency affecting all the parties concerned, separate and independent areas shall be assigned, in the first instance, to each company. Its undisturbed possession will thus depend upon its efficiency and good behaviour, a condition which is further safeguarded by the suggestion that a larger area than that comprised in the Order shall be provisionally assigned to each of the companies, such extension of area to overlap the territory assigned to one of the others, so as to create what the Report felicitously calls a "potential competition" in case it is ever required. As the Act does not in any case confer exclusive rights, such as are possessed by gas and water companies, the plan approved by the Kensington Vestry is perhaps as near an approach to a monopoly as the electric companies can hope to obtain. With regard to the assignment of the several areas there will probably be some heartburnings and disappointments. All we need say on the subject is, that in examining and reporting upon the merits of the several claimants the Committee appear to have done their best to arrive at a sound decision, and have given their reasons for it frankly and fairly, though possibly in one or two instances with insufficient knowledge.

On the question of charges, too, the Committee cannot be blamed for adopting a suggestion which has actually been put into their heads by one of the competing companies, namely, that of a sliding scale such as prevails with the gas companies. A difficulty is foreseen in the case of electric supply, which is a new industry, seeing that no one can accurately estimate beforehand or ascertain afterwards the amount of capital properly and necessarily spent on the undertaking. Perhaps it is this uncertainty on which the House-to-House Company reckons in offering to diminish or increase the standard price, subject to a decrease or increase in the standard rate of dividend (10 per cent.) Has the House-to-House Company forgotten, when thus putting itself on the same footing with the gas companies in respect to prices, that it is on a totally different footing in respect to tenure? The older supply corporations have a permanent monopoly, whilst the new corporations which are now being created have rights only—and those not exclusive—for a limited period of at most forty-two years—a period the authorities desire to cut down even still further. There is nothing essentially unfair in the Vestry accepting these terms; but by accepting them in detail, as proffered by the House-to-House Company, the Kensington companies may be not only doing a wrong to themselves but to their brethren who are seeking Provisional Orders elsewhere.

On the subject of overhead wires the Vestry appear to have been influenced by panic. Without a vestige of evidence one way or the other they recommend that no company shall be at liberty to carry wires otherwise than underground, and that all existing overhead wires be removed on the Provisional Order taking effect. In a note we are told that all the undertaking companies practically agree to this requirement, and reference is made to their answers to questions tabulated in an appendix. Turning to page 22, we find that the answers, where any are needed, are rather conditional than positive, one of them being "Overhead wires will be removed as soon as underground mains system overtakes them." If the Vestry are satisfied with this answer, so are we; indeed, it is the most rational answer that can be given in the circumstances; and as it is not very likely the Vestry will use their powers, even if obtained, of constructing "culverts and channels to hold electric mains," the companies may safely be left, in this particular, to the mercies of the Board of Trade.

With regard to the Purchase clause we very much regret to find, from a statement towards the end of the Report, that the Vestry has not only set its mind upon reducing the period from forty-two to twenty-one years, but that it is not unlikely to carry its point. The Report states that the Committee have reason to believe that "all the companies would consent" to this curtailment. If this is the case we must again exonerate the Vestry from blame in the matter; but it is almost past belief that the very people who protested against the twenty-one years' limitation of 1882 should now deliberately abandon the concession of forty-two years obtained in 1888—a concession for which they had been stenuously fighting for six years past, and without which they were said to be unable to undertake any business at all. We shall be greatly astonished if these electric lighting companies have stultified themselves in this cynical fashion; and we should imagine that the profession and trade of electrical engineering throughout the whole country will indignantly refuse to accept it as a precedent for their own action outside the Parish of St. Mary Abbotts, Kensington. Similar conditions, it will be seen, have been introduced by the Committee on the lighting of the City area, whose Report also we summarise and print this week.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section III.—Magnetic Fields of Coils and Solenoids.

(*Continued from page 335.*)

144. *Direction of Magnetic Field in the Region of a Circular Current.*—Only a few months back the attention of the scientific world was directed once more to the life and labours of that great French mathematician and physicist, André Marie Ampère, the occasion being the unveiling of a statue in his memory erected by his fellow citizens in the city of Lyons. Immediately upon the news reaching Paris of Œrsted's discovery of the action of a current of electricity upon a magnetic needle towards the close of 1820, Ampère keenly followed up the subject, and very soon after gave to the world his electrodynamic theory, embracing the laws governing the mutual action between conductors carrying currents of electricity, based upon which we now have some remarkable current and electricity meters. Among these may be cited Siemens' electro-dynamometer, in which a current circulating in two coils, one fixed and the other movable, is measured by the amount of mechanical force required to counteract their mutual attraction. Or, again, the Ferranti meter, in which the current to be measured passes radially through a mercury bath, and then through a fixed coil outside it, causing rotation of the mercury, and setting in motion a train of clockwork indicating the quantity of electricity passed

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through the meter in a given time, and more recently the beautiful ampere balances of Sir William Thomson, in which the movable coils are at each end of a balance arm, and are attracted, one up and the other down, by a pair of fixed rings, embracing each movable coil. In this instrument a sliding weight is moved along the bar until a position is found, such that the balance arm is restored to equilibrium, and this position indicates on a scale the strength of current passing through the coils. Measuring instruments such as these, designed on the principle of the attraction between fixed and movable portions of an electric circuit, have the invaluable property of being capable of measuring the strength of currents *alternating* in direction as well as direct currents.

But, further, Ampère gave a precise explanation and theory of the magnetic character of electrical circuits; in fact, he showed that when a conductor carrying an electric current is bent into the form of a single ring or a series of rings side by side, such as a spirally-wound coil, that the behaviour of such is identical with the behaviour of a magnet. The spirally-wound coil, in which a current is circulating, acts, as regards attraction, repulsion, and external magnetic effects, exactly like a cylindrical bar magnet, presenting, as it does, at its extremities north and south magnetic poles. Similarly, a ring-shaped coil, through which a current circulates, presents opposite magnetic poles at its two faces, being, in fact, identical in magnetic effect to a thin slice off a cylindrical bar magnet. Such a thin slice or disc of magnetised iron is called a *magnetic shell*, and the ring-shaped coil carrying a current which is equal in magnetic action to such a shell is termed its *equivalent* magnetic shell. Further, every plane closed circuit of whatever external shape can be shown to have its equivalent magnetic shell.

It is with this part of the subject that we have now more particularly to deal, and to make the subject as easily understood as possible we shall first consider only the *direction* of the magnetic field in the neighbourhood of a circular current, and then show how its exact value at different points may be determined by Ampère's laws. Suppose, first, a portion of a conductor carrying a current, bent into a ring as in Fig. 128, the

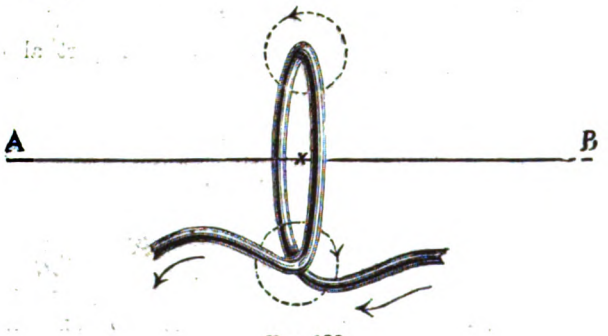

Fig. 128

arrows representing the direction of the current. Now what is most useful to know with reference to the action of galvanometer coils is the direction and magnitude of the magnetic field along what is called the axis of the coil. The axis of a coil is an imaginary line in the same position with regard to a coil as a shaft is in with regard to a pulley keyed to it—that is, it is a line (such as the line A B in the figure) whose direction is at right angles to the plane of the coil, and which passes through its centre. Lines of force will enclose the conductor in circles at every point throughout its length. Now let us consider separately for a moment those circles of force which lie in the same vertical sectional plane of the ring, one at the top and the other at the bottom, and let us examine the magnetic field they create along the axis A B. Having found this we can add up the fields set up by every sectional plane of the ring, for every one of these planes acts alike. The direction of the circles of force will be understood to be as indicated in the figure, because the current is flowing *towards* us in the top of the ring, and *away* from us in the lower portion. Take, first, the action of the upper portion of the ring and let us consider it separately, the section of the wire being represented at W (Fig. 129). On the axis A B let us mark out a series of points (1 at the centre and 2, 3, 4 on each side of it) at which to determine the field set up. Circles of force emanating from the conductor W as centre will pass through all these points. Now we have already stated that when a force acts along a circle, its direction at any given point is at a tangent to the circle. We have familiar examples of this tangential action in centrifugal separators. For example, if the dotted circle in Fig. 130 repre-

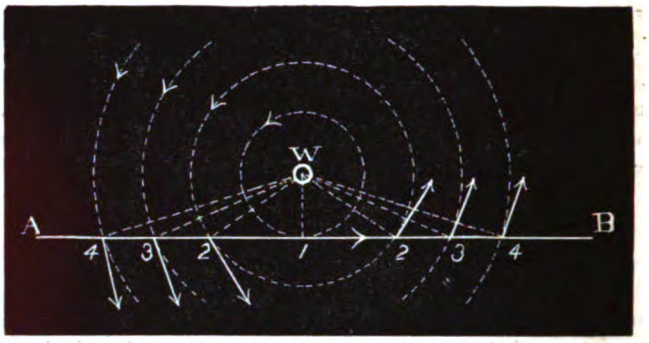

Fig. 129.

sents a body revolving in the direction shown, the forces acting at any moment when it passes the points A B, C D, are tangential to the circle, or at right angles to the radii at those points, and this is the case for *any* point we may take on the

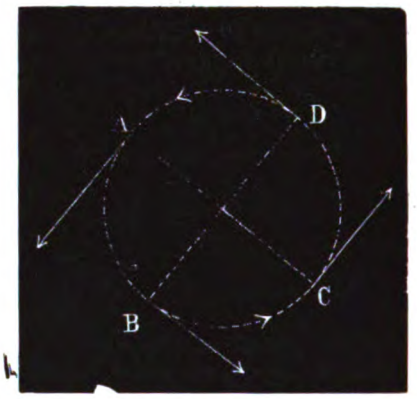

Fig. 130

circle. Applying this principle to the circles of force round the conductor, we find the *direction* of the magnetic forces by drawing lines at *right angles* to the radii of the circles passing through the various points, and assigning to them a direction agreeing with the direction of the circles of force. It will be noticed, then, at the point 1, which is at the centre of the ring, the direction of force is along the axis of the ring, but as we get further away from the plane of the ring the forces become more and more nearly at right angles to the axis. Now,

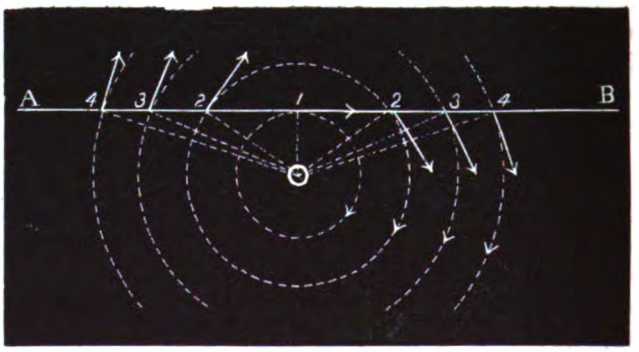

Fig. 131

consider the action of the circles of force emanating from the lower portion of the ring. Fig. 131 represents this action, where 1, 2, 3, 4 are the same points as chosen above, and the circles of force are in the opposite direction. Proceeding in

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the same way, we find that at the point 1 (the centre of the ring) the force acts along the axis of the coil *in the same direction* as the force due to the upper portion of the ring, and the forces at the other points act at the same angles relatively to the axis as those above. Now combine the two sets of forces by setting them out together along the axis (Fig. 132), the upper and lower sections of the conductor composing the ring being indicated at W W. Here we find that although the forces diverge more and more from the axis as we proceed further away from the plane of the coil, yet each pair of forces has its *resultant along the axis*, and all resultants are in the same direction as the two forces at the centre due to both portions of the conductor. Further, the resultants of these pairs of forces become less and less as we take them further from the plane of the

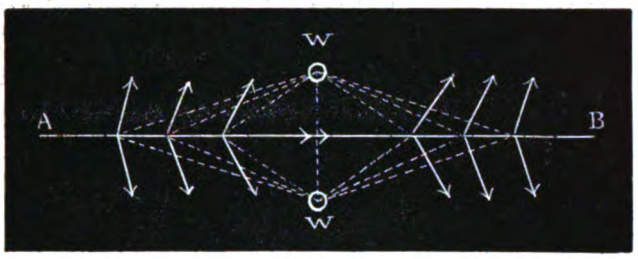

FIG. 132.

coil, because the forces themselves act more and more in a direction *opposing* each other, and therefore tend to reduce the intensity of the resultant horizontal forces.

(To be continued.)

"NOTES ON THE DESIGN OF ELECTRIC MOTORS."

On Wednesday, the 30th ult., at the City and Guilds of London Institute Old Students' Association, the following discussion took place upon Mr. Albion T. Snell's Paper read to the Association on the 16th ult. (See *Electrician*, January 18th.) The President (Mr. Thomas Adams) occupied the chair.

DISCUSSION.

Mr. W. B. ESSON*: Taking the principle of reversibility, Mr. Snell of course finds that for a series motor there is no critical current—that is, any current above that required to overcome its friction will make it run. But for a dynamo a current lower than a certain value, called the critical current, is impossible. From this Mr. Snell seems to think that there is something radically wrong in the principle of reversibility, but I think this is a mistake. I made some experiments years ago to ascertain the effects of the reactions of the armature on the field, and concluded that in any machine run both as dynamo and motor with similar currents the effects as regards the weakening of the field were exactly similar. The case stands thus: Take a series machine and send a certain current through the field-magnets and armature. There is undoubtedly a delay in magnetisation, as pointed out by Ayrton and Perry some years ago, but I do not attach importance to this effect in continuous-current machines. Although negligible in these, in alternate machines, however, the magnetic delay becomes enormously important. Well, neglecting this delay, let us send, in both motor and dynamo, the same current through the magnets and armature; it stands to reason that the fields being identical whichever way the armature turns the reaction must be exactly the same, provided that the back lead in the motor is equal to the forward lead in the dynamo. In a motor the only difference is that the armature runs round the other way, the magnetisation of the system and distribution of the field being the same in both cases. In the experiments mentioned, a dynamo was taken with a Gramme ring core saturated to a fairly high degree. This was run to produce several different currents. As a motor it was run at the same speed, and braked until the same currents flowed as were generated when it ran as a dynamo. With the current flowing in the same direction through the machine, the armature revolved, of course, in the opposite direction, the brushes having the tips rounded so that their ends did not turn up with the reversal. If V_1 and V_2 are the differences of potential at the terminals of the dynamo and motor, then I found in each case that—

$$V_1 + C R = V_2 - C R,$$

where C was the current and R the resistance of the machine. I concluded from this that the reactions were in both cases similar, and that the delay in the magnetisation of the armature core was also inappreciable.

* Mr. Esson's speech was delivered at the first meeting after the reading of the Paper.

Now we come to the self-induction. In this direction I have been making several experiments lately, and find that in armature cores saturated to 16,000 or 18,000 C.-G.-S. the effect of self-induction may be entirely neglected. The experiments are made thus: The machine is separately excited, and run without any lead on open circuit, the E.M.F. and speed being noted, also the ampere-turns on the field. We now let a current flow through the machine, and note the increase of excitement required to bring the E.M.F. to its previous value—that is to say, the difference of potential at the brushes when running at the same speed is equal to its previous value *minus* the current into the resistance of the armature. There is no lead to the brushes, and therefore any weakening of the field is due to self-induction; and I find that at 16,000 or 18,000 C.-G.-S. the number of turns required to bring the potential when the current flows up to its former value is inappreciable, while at lower degrees of saturation a certain number of ampere-turns have to be added, which get larger as the saturation is reduced. To get $V_1 + C R = V_2 - C R$ the core must, of course, be well saturated, so that self-induction does not come into action.

Regarding the effect of the armature field on the main field, I disagree entirely with Mr. Snell. It is quite true that Ayrton and Perry showed that the effects due to both might be added if the motor were worked with a forward lead; but, if I recollect rightly, Ayrton and Perry stated that under usual conditions of work the brushes must have a negative lead. With this you must have a weakening of the field. You cannot have an increase; it is a physical impossibility. I might say that one of the reasons of a shunt motor governing so perfectly is due to this weakening effect on the field of the armature windings. As the current rises the field is weakened, and the effect is similar to that of a series coil wound on the magnets in the reverse direction to the shunt. For constant speed we require, therefore, no compound winding, but only a particular relation of field to armature. I have seen a shunt-motor in which the speed actually increased as the load was put on.

As to the ratio of field-magnet to armature cross-section, it is worthy of note that the cross-section of armature core can be varied very considerably without affecting to any considerable extent the number of lines of force through it. This arises from the fact that the ampere-turns required for the induction through the core is only a fraction of the ampere-turns on the whole machine. In investigating this my firm constructed two armatures—one had a cross-section equal to ·6 that of the magnets; the other was ·8. The windings were similar, and so was the length; in fact, the only difference was that the hole in the centre of the armature was in one of them smaller. Although the increase in the cross-section was very considerable, the maximum increase in induction due to similar excitements was in the core of larger section only from 5 to 6 per cent. The gain is therefore so small for considerable increase in weight that I think it is scarcely worth while making two types. For "useful" lines induced by the current in the armature core Mr. Snell ought to substitute "useless" so far as adding to the E.M.F. is concerned, for, as I have already shown, the field is always weakened by them, not strengthened.

I may say that it is a very difficult thing to calculate the magnetic leakage before the machine is built, but it is very simple to measure the leakage afterwards, and from that it is tolerably easy to deduce the leakage in other machines, both of the same and modified types. One point is worthy of remark. Taking the single horseshoe magnet, suppose that in such a machine the ratio of the total lines of force induced in the magnet limbs to those passing through the armature core is 1·32. Now, imagine that you make a mistake in your calculation before the machine is made by assuming the ratio at 1·2, instead of 1·32. The error in the assumed leakage is about 10 per cent., but the difference in the E.M.F. of the machine due to having made this error, and deduced the ampere turns accordingly, will only be about 2 per cent. The reason of this is that the number of ampere-turns required for the induction in the magnets themselves is fractional as compared with that required for the whole machine.

If the terminal difference of potential = V is the same when the machine is driven as both dynamo and motor, the respective speeds for similar currents will be in the ratio $V + C R : V - C R$, the dynamo, of course, being always the higher. I may mention that the electrical efficiency of a motor is always greater than that of a dynamo at the same speed and current, the efficiencies standing in the ratio of $\frac{E}{E + C R} : \frac{E - C R}{E}$, where E is the E.M.F. generated in each case. Of course it makes no difference to the E.M.F. whether the armature is belt-driven or current-driven, provided the fields are in each case the same.

One of the chief reasons for the ampere-turns having to be increased over that shown by the calculation is because in the calculation the demagnetising effect of the armature upon the field-magnets is neglected. This weakening effect is due to the lead of the brushes. In the Manchester machine, for instance, Dr. E. Hopkinson tells me that there are as many ampere-turns of series as of shunt wire, and the chief use of the series wire is to compensate the weakening effect produced by the current flowing through the armature.

Mr. Snell says, referring to the method I use, that I neglect leakage and self-induction. As a matter of fact, I neglect nothing, or rather I only neglect those things that are negligible. Self-induction is negligible, and the leakage I take always at one fixed ratio, an error in this producing, as I have shown, very small effect on the output of the machine.

In conclusion, I again express my regret at the absence of the author. Though my remarks have been of a somewhat critical character, it will be understood, I hope, that concerning most of the points of which I have not spoken I have only to utter unqualified praise. I have called attention only to those points to which I in some degree take exception.

Prof. AYRTON described the Paper as a very practical Paper by a very practical man. Such a contribution from one of the old students not only did great credit to the Association, but was of real value to the profession.

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Mr. Snell's labours for the past few years in Mr. Immisch's factory had so thoroughly borne out the view that was put forward some seven years ago by Prof. Perry and himself as to the difference that ought to be borne in mind as to the construction of a good dynamo and a good motor, that he did not think they were likely to quarrel upon side issues. In 1882, when Prof. Perry and himself put forward this idea that the motor and the dynamo should be constructed in a different way, they were regarded as rather revolutionary seceders from the orthodox camp, and he did not suppose (in fact, he felt sure of it) that they had yet been received back quite with favour among the orthodox. It was, therefore, a matter of great pleasure to them to find from Mr. Snell's work that henceforth heterodoxy must be regarded as orthodox (applause). Mr. Esson's remarks at the previous meeting were of extreme value, because they came from another practical man (hear, hear). The work that practical men were doing, the fact of their being able, somehow or other, to find time in the exigencies of commerce and the drive of business to make scientific experiments, filled him with the utmost admiration. If he made any remarks which appeared to savour of a critical character, it must be understood that, so far from being hostile, his criticism would merely be suggestions thrown out for the purpose of enabling practice and theory to go hand in hand in the endeavour to obtain a really good motor, whatever might be the construction they were ultimately led to adopt. The results of the experiments made by Mr. Esson were a little staggering. Their effect was that if a certain current were sent through a machine running at a certain speed, the electromotive force developed in that machine was the same whether it was working as a dynamo or as a motor. If that conclusion was universally true, then the whole theory that Prof. Perry and himself put forward in 1882 as to the action of the armature in a motor would be groundless. Before the end of the previous meeting he had been able to see where the fallacy in Mr. Esson's conclusions lay. Mr. Esson had been expermenting with dynamos used as motors, and not with motors used as dynamos, and the difference was a very important one (hear, hear). The armature of a good modern dynamo, as they all well knew, was wound with but a few convolutions of wire, and was a weak electro-magnet. Therefore, if Mr. Esson had succeeded in proving that the addition of a weak electro-magnet to a strong magnet—whether with a plus sign or a minus sign—induces but little change, that does not really add much to our information as to what happens in a motor. Immediately after the meeting he suggested to Mr. Mather that he should make the same experiments that Mr. Esson had, and that he should make them not with a dynamo but with a motor. An Immisch motor was selected for the experiments. Mr. Mather, one of his assistants, together with two of the students, Messrs. Drew and White, made exactly the experiments described by Mr. Esson—that is, they ran that motor both as a motor and as a dynamo. As a motor of course it was run by the current supplied, as a dynamo it had to be driven by an independent source of power. The current was maintained the same in the two cases, and the speed was maintained the same. Various currents, as a matter of fact, were used in the different experiments, but the same set of currents were used when the machine was run as a dynamo as when it was run as a motor. The result completely disproved Mr. Esson's statements, as the following table would show :—

Experiments with an Immisch Motor. Speed throughout 1,400 Revolutions per Minute.

Series A.—Armature turning WITH *the brushes.*

I.—Run as a motor.

Amperes.	Volts at terminals.	Volts used in armature.	E.M.F. developed in armature.
12	31	2·3	28·7
14·3	35·5	2·7	32·8
15·2	38·5	2·9	35·6

II.—Run as a dynamo.

12	20·5	2·3	22·8
14·3	24·4	2·7	27·1
15·2	26·9	2·9	29·8

Resistance of armature in experiments I. and II. was 0·189 ohm.

III.—Run as a motor.

12	30·2	2·5	27·7
14·3	35·8	3	32·8
15·2	38	3·2	35

IV.—Run as a dynamo.

12	20·5	2·5	22·3
14·3	23·5	3	26·5
15·2	26·5	3·2	29·7

Resistance of armature in III. and IV. was 0·287 ohm.

Series B.—Armature turning AGAINST *the brushes.*

V.—Run as a motor.

Amperes.	Volts at terminals.	Volts used in armature	E.M.F. developed in armature.
12	30·8	2·64	28·16
14·2	35·2	3·15	32·07
15·2	36·2	3·34	32·86

VI.—Run as a dynamo.

12	22·3	2·64	24·94
14·3	25·8	3·15	28·95
15·2	27·7	3·34	31·04

Resistance of armature in V. and VI. was 0·22 ohm.

If now we compare I., which is the most favourable when the machine was running as a motor with the brushes, with VI., which is the most favourable when the machine was running as a dynamo against the brushes, we have :

Amperes.	E.M.F. developed in armature of Motor.	Dynamo.	Difference in percentages of smaller.
12	28·7	24·94	15
14·3	32·8	28·95	13
15·2	35·6	31·04	15

This proves conclusively that there is a stronger field when the machine is used as a motor than when it is used as a dynamo.

These experiments also disposed of Mr. Esson's objection that self-induction was of no consequence. Mr. Esson mentioned two experiments in which he found that $V + C R = V_1 - C R$. He concluded, therefore, that the effect of self-induction might be neglected, and that the delay in the magnetisation of the armature in appreciable. Well, of course, that was disposed of in exactly the same way. Mr. Esson was dealing with an armature with a small number of convolutions, not with a motor which had many convolutions. With an armature having a small number of convolutions the self-induction, which depends on the square of the number of convolutions, is, of course, of very little consequence. But that did not apply to a motor. The addition of the armature field is a very distinct feature in the motor, and he believed the self-induction might also be of considerable importance.

In the beginning of Mr. Snell's Paper he said "It is now generally admitted that the effect of self-induction in the dynamo armature is to increase the lead, while in the motor it tends to diminish it." He did not know that he could quite agree with that statement. The effect of self-induction is twofold. It is, of course, to diminish the current which passes with a given potential difference and a given resistance. It also is to delay the current. It is a little difficult to say what is the resultant effect. The two effects would somewhat oppose one another. The effect of delaying the current, no doubt, is to shift the poles round, and therefore to increase the lead of the dynamo and to diminish the lead of the motor. For with a positive lead in a dynamo shifting the poles round will take the line of commutation farther from the neutral position, whereas with a negative lead in a motor the shifting of the poles will bring the line of commutation nearer to the neutral position. But if they took into account the weakening of the current due to self-induction—possibly, however, that was not what was intended—then he was not so sure that they could put it exactly in the same way. It was most important to remember, when speaking of self-induction, that there are always two effects—the weakening, and the retardation ; and they may or may not help or oppose one another. Mr. Snell goes on, "Mr. Mordey has pointed out that in the generator the effects of self-induction in the armature winding are opposed to those of the Foucault currents in the core ; but in the motor they tend to increase each other." There, again, it is a little complicated as to what is exactly understood to be the effect of self-induction. There is no doubt about this, that the Foucault currents in the core of an armature are in the same direction as the currents in the windings, and therefore whatever effect the currents in the winding may have in changing the lead or diminishing the field, whatever it may be, there will be the same sort of effect produced by the currents in the core ; and, therefore, there is no doubt whatever that with a dynamo the currents in the core tend to weaken the field as well as the currents in the windings. On the other hand, the currents in the core in a motor will also tend to weaken the field, whereas the currents in the armature increase the field, as the experiments of Mr. Mathers show. If, instead of saying "the effect of self-induction" Mr. Mordey had spoken of the effect of the currents in the core and the currents in the armature windings he would perfectly agree. Mr. Snell has pointed out that it is of value to short-circuit the coil of a motor when it passes under the brushes, and not good to short-circuit the coil of a dynamo armature when it passes the brushes. In the Immisch motor the coils when they pass the brushes are short-circuited ; and that is of distinct value for this reason, that when you short-circuit those coils you get a current in the coil which is opposed to the current in the armature itself, and, therefore, the shifting of the field due to the currents in the armature is balanced by the current to a certain extent in the short-circuited coil ; whereas in the dynamo both currents would be in the same direction. Practically, then, short-circuiting the coil in the amature of a motor enables you to keep the brushes in a fixed position, whereas if you short-circuit the coil in the armature of a dynamo it tends to make the lead increase more rapidly with increase of current in the armature. Now, of course, one of the great objects that has been aimed at in modern machines, dynamos and motors, is to enable you to have the brushes in a fixed position without sparking when the current in the armature is increased. That object is approached more nearly by short-circuiting the coils in the motor, and would be departed from by short-circuiting the coils in a dynamo. He would like to know why Mr. Snell said "the field strength has to be relatively greater as the size of the machine is increased." It would be very advantageous if in his reply he could point out why he had been led to that consideration. Of course he might have been led to it simply by commercial reasons, because the expense of making a large armature is naturally considerable. Theoretically he did not see why there should not be a relatively large armature for a large motor as well as for a small one. Mr. Snell spoke of the E.M.F. of the motor as being the B.H.P. divided by the current. Of course that is not the back E.M.F. of the motor. It is a kind of imaginary E.M.F. Then Mr. Snell took the E.M.F., which he put as equal to the potential difference of the terminals minus the current and the resistance plus L_m, while L_m is the value of the reactions of the motor armature. He did not know that they could subtract from the E.M.F. in that way and hope to get right results. It seemed to him that that

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became rather complex, and would possibly lead them into difficulty. He was very glad to see that Mr. Snell had used the method that Prof. Perry and himself suggested in their original Paper for plotting out the results, namely—

$$\frac{E}{n}, \frac{e}{n}, \frac{\text{B.H.P. } 746}{n\,c}.$$

That method was no doubt an extremely good one for trying to find out the curves of a particular machine. He could not sit down without expressing the admiration which they must all feel for the labours of Mr. Snell (applause), for his kindness in bringing his Paper before them, and especially he might end by saying—as, indeed, he began—that any remarks that he had made, apparently of a critical nature, were merely made suggestively, and not in any hostile spirit.

Mr. RECKENZAUN said he had perused the Paper several times, in the hope of finding some points about which he might disagree; but he had been unable to find much fault with the practical part of the Paper. His own views, based on long experience, coincided with those expressed by Mr. Snell. The fact that there was a decided difference between the reaction of the armature, when the same machine is working as a motor or as a dynamo, dawned upon him at a very early period in those early days—in fact, when the Paper of Profs. Ayrton and Perry was published. He made that Paper a kind of text-book, upon which he had been working more or less ever since; he considered Mr. Snell's Paper an excellent supplement to it (applause). Some six years ago he used one of his small motors of 1½ horse-power capacity to work as a generator. He wanted to generate a current out of a very small dynamo. He found that the same machine when running as a dynamo required 60 per cent. more speed to produce the same E.M.F. That surprised him very much at the time. In order to ascertain whether this result was merely due to the design, he made tests with every kind of dynamo then at his disposal. In conjunction with Mr. Capito, he tried each machine as a motor, then as a generator, and compared the results Among these machines were some of Bürgin's, Siemens', and De Meritens'. Of these machines, the Bürgin had the heaviest field-magnets, and he thought that this would give, probably, the smallest differences in the results. It was a series machine. The results he obtained with the Bürgin machine were as follows:—Running it as a motor, he obtained 10·76 revolutions, 17·8 amperes, 116·2 volts at the terminals, 2·67 electrical horse-power, 2·15 B.H.P. Running it as a generator 10·86 revolutions (which was as near as he could get it to the other) 17·8 amperes, 84·5 volts, 1·6 electrical horse-power. Then he made another experiment, keeping the electromotive force and the current as constant as possible. These figures would show how the speed varied. When running as a motor it made 728 revolutions, 19·4 amperes, 83·5 volts, 2·2 electrical horse-power, 1·46 B.H.P. Running it as a generator, it made 1,100 revolutions, 19 amperes, 85·8 volts, 1·67 electrical horse-power. In conclusion, he congratulated the author and the profession at large on this very excellent Paper (applause).

Mr. E. W. SMITH referred to the short-circuiting in the dynamos caused by the brushes. There were two arguments for it and one against it. Prof. Ayrton had given the one against it. Prof. Silvanus Thompson, however, holds that you should short-circuit the coils just so long that you can get up the same current in the opposite direction ready to fall into the circuit, so that there should be no effect of self-induction when the coil is passed into the other side of the brush. Another point was that though in the motor short-circuiting the coil has an effect on the field, in the dynamo it has not much effect on the field, because the armature field is so weak compared with the magnets. Of course the factor which determined how long you should short-circuit was whether you prefer some sparking and little effect of self-induction, or a greater self-induction effect and no sparking.

Mr. GUMPEL said that Mr. Snell's Paper gave them valuable information in connection with one of the most important subjects electricity could bring before them. It might be a dream, but he thought that electric motors would be in the future the principal point to which electrical engineers would direct their attention. Every indication pointed to that. The advantage of electricity would force itself upon the public at large, and then electrical engineers would be called upon to assist in dispensing with many of the cumbrous instruments at present used in daily life. Generally he agreed with Mr. Snell; this agreement might not, however, mean much, because there was hardly a second man in England who had such a long experience in motors as Mr. Snell. Having said that he would become heterodox, and attack the whole system in which these questions are dealt with. He disapproved of Mr. Snell's very first sentence:—"In discussing the design of electric motors, it will be necessary to first of all consider the relation between the dynamo and the motor." He entirely disagreed with that. He believed that the electric motor would find no greater drawback than its genesis out of the generator. If there were no generators, but simply electricity and its application, they could most decidedly attach electro-motors in a different manner altogether. He was, of course, referring to the reversibility of the dynamo. Prof. Silvanus Thompson, in a Paper read before the Society of Arts, stated that Clerk Maxwell, on being asked what he considered to be the greatest discovery in the last 25 years, replied:—"The reversibility of the dynamo." He wrote to *Knowledge* stating that surely Maxwell could not have said such a thing. Lenz's law, which was enunciated in 1834, contained within itself the reversibility of the dynamo.

Mr. KILGOUR suggested that in the case of a small motor the interest taken at the rate of 10 per cent. or so, and spread over the 2,000 hours or 1,000 hours a year, came to be a pretty considerable fraction of the electric energy put in. In the case of an 8 horse-power motor, it would come probably to as much as 15 per cent. That would have a considerable influence in transferring the point of maximum efficiency, and would bring it nearer to the point of maximum output.

Dr. WALMSLEY said that all his points had been anticipated by one speaker or the other. He congratulated the Association upon having such a Paper brought before it, and he congratulated Mr. Snell upon the very admirable Paper he had given them. Prof. Ayrton referred to the inadvisability of calling the second equation $\frac{\text{B.H.P. } 746}{n\,c}$ the back E.M.F. of the motor. Mr. Snell had explained to him that he did not intend it to mean that, only in the Paper by some oversight it distinctly appeared as the internal E.M.F. of the motor. If that were so, of course then the efficiency of the motor would be 100 per cent. He did not, however, object at all to expressing the loss in volts. They would notice that in so doing there was to some extent a distinct departure from the ordinary way of expressing the loss. If they took the L_d or the L_m which represented waste—he would not say "waste energy" because they were in volts—but if they took waste energy expressed in watts, and divided it by the current in the armature, then they had the expression L_d or L_m. So far he cordially agreed with Mr. Snell in thus expressing that waste energy. Its usefulness was emphasised by the curves which were given at the end of the paper. He would write the equations in this way—E_m the internal E.M.F. of the motor really equal to the E_T minus C R, which it must be. Then on the other side B.H.P. 746, divided by C plus L_m. This, therefore, would be the equation for the motor

$$E_T - C\,R = E_m = \frac{\text{B.H.P. } 746}{C} + L_m.$$

Part of that L_m was due to mechanical loss in the motor. Therefore it was a distinctly new way of writing that, except so far as anticipated in a curve of *that* kind [pointing to diagram given on page 314 of *The Electrician*.] The dynamo equation would be

$$E_T + C\,R = E_d = \frac{\text{B.H.P. } 746}{C} - L_d.$$

In Mr. Snell's equations there was no hint given as to how they were to ascertain what the speed of the motor ought to be. He rather fancied that, unless they got it out of those curves in some way, they could not determine by these equations whether the speed of the motor was greater than it ought to be or whether it was less (applause).

Mr. ESSON: About the Immisch motor; I should like to ask Prof. Ayrton a question. Was it a drum armature or a ring armature?

Prof. AYRTON: A drum armature, I believe.

Mr. ESSON said another question he would like to ask was this. When Prof. Ayrton sent the currents through the machine as a dynamo was the lead the same amount in a forward direction as it was in a back direction when he used it as a motor? He would like to make a few remarks in addition to those he made on the last occasion. The first point was with reference to the drum armature. Of course, in a drum armature the saturation was much less in the core than it would be in a ring armature, and his experiments were made with a ring armature. In the Paper which detailed those experiments he put in a term for the self-induction, as the expression was meant to be a general one, which would include cases in which the armature was saturated only to a small degree. Of course the self-induction became very important when they had a low degree of saturation in the armature. Prof. Ayrton said in all cases the E.M.F. of the motor was very much higher than that of the dynamo; but he (Mr. Esson) would point out that when they took the difference of potentials at the terminals of the motor and deducted from that C R, they were not then measuring the back E.M.F. of the motor. In sending a current through the motor they had to overcome, first, the electrical resistance C R; secondly, the back E.M.F. of the motor itself; thirdly, the E.M.F. due to self-induction. Therefore they were measuring the E.M.F. of the motor, plus something which depended on self-induction. Coming to the dynamo, when they took the difference of potentials at the terminals of the dynamo, and added C R, they had not got the E.M.F. of the dynamo, but they had got the E.M.F. minus the term which depends on self-induction. He contended that Prof. Ayrton in his experiments had been really measuring the self-induction of the machine, and the difference in the volts which he had got was equal to twice the E.M.F. due to self-induction. That was only on the supposition that he used the same back-lead in the motor as he did forward lead in the dynamo. It seemed to him to be a very simple thing to measure the self-induction, and it really ought to be measured. Then Prof. Ayrton would know exactly how much to put down to this, and how much to credit to the actual strengthening or weakening of the field. Mr. Snell had told him before the discussion that night that he had measured the back E.M.F. in the machine running as a motor and the E.M.F. in it running as a dynamo, deducing therefrom the strength of the field. In the one case—in the dynamo—he found that the E.M.F. was 14, while in the motor it was 14·9. Was that a drum armature?

Mr. A. T. SNELL: It was a ring armature.

Mr. ESSON said it was not very highly saturated, because the effective magnetism in C.-G.-S. units comes out at 13,720 for the dynamo and 14,602 for the motor. With reference to the compound windings of the Manchester dynamo of which Prof. Ayrton had spoken, it might be that the series was about half the shunt. That was a very common proportion. It was a proportion which they had in the Phœnix dynamos; but of course the series turns depended upon a great many things. They depended upon the turns in the armature; in fact, in their dynamos the series-turns in the magnets had always a certain fixed relation to the windings on the armature, and it depended also upon the degree of saturation and upon the self-induction. He had measured the compensation required and he had also measured what was required to raise the E.M.F. of the machine. It was a very easy thing to do. They simply took the saturation curve in the machine by separately exciting it with no current flowing in the armature. You mark the position of 100 volts, and then you see how many ampere-turns were required to raise it to, say, 105. When you have done this you find how many ampere-turns are required in the field-magnets

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to raise the E.M.F. from 100 to 105 volts with the full current flowing. He found in the Phœnix machines that the waste turns—they might say the compensating turns, the turns really required to counterbalance the weakening effect—were about equal to the amount of ampere-turns required to raise the E.M.F. He also, while he was experimenting upon that subject, consulted Mr. Kapp, Mr. Swinburne, Mr. Sellon, and some other of his friends, and in most cases they had found about the same effect. The most peculiar instance was furnished by the Victoria dynamo, for there he thought the turns required to compensate the windings in the armature were four times the amount required to raise the E.M.F. from 100 to 105 volts when the machine was running with no current in the armature (applause).

Prof. AYRTON said with reference to Mr. Esson's pertinent question, the lead was unaltered during the whole of the experiments as a matter of fact because it could not be altered. The Immisch motor did not require an alternation of lead to vary the current. The armature had been run both ways, so that any advantage that could be obtained by varying the lead would have to be obtained either for the motor or for the dynamo. The numbers that it would be most right to take would be the highest values of back E.M.F. in the motor when run one way and the highest values of forward E.M.F. in the dynamo when run the other way. The highest values of the forward E.M.F. when the armature was run as a dynamo one way were lower than the back E.M.E. of the machine when the armature was running the other way. There was no question, therefore, as to the lead being suitable for the machine as a motor and not suitable for the machine as a dynamo. That answered Mr. Esson's question number one. Mr. Esson said if V_1 and V_2 were the differences of terminals, then

$$V_1 + C\,R = V_2 - C\,R,$$

where C was the current and R the resistance machine. All he could say was that they found it was not. They found that $V_1 + C\,R$ was different from $V_2 - C\,R$. Mr. Esson said, and it was perfectly true, that there might be a turn added for the effect of self-induction, but did not he rather uphold that self-induction was of no consequence in these machines? On the last occasion Mr. Esson said, "I concluded from that that the effect of self-induction might be neglected." Could not they with the same approach to truth conclude that the effect of self-induction might be neglected?

Mr. ESSON: No.

Prof. AYRTON said of course he did not want to in any way beg the question by a little bit of special pleading; but he did not think Mr. Esson had proved his point. Probably Mr. Esson had the same opinion about their experiments. The proper way to write what Dr. Walmsley had written down was not to express that loss as an E.M.F. or a potential difference. He thought that was rather misleading; he did not imagine that Mr. Snell meant by E_m what was commonly called the back E.M.F. of the motor. Mr. Snell meant that it was a kind of fictitious back E.M.F., but he (Prof. Ayrton) thought it was a mistake to introduce that fictitious back E.M.F. The proper way, he believed, was as Prof. Perry and himself wrote it in the Paper some seven years ago; that was to say, that C V (the watts applied to the motor) was used up in certain definite ways—all of which might be written down without difficulty. He did not know that there was any actual loss of volts due to reactions in the motor. What happened was that a certain amount of the mechanical power developed was used in grinding the spindle of the motor against its bearings, and in generating Foucault currents instead of being usefully given to the tool or machine driven by the motor. Commercially, that led, no doubt, to a distinct waste of power, but it was, he thought, a mistake scientifically to say that the motor did not develop a certain amount of mechanical power because that power was subsequently employed uneconomically. The fact was they used a part of the power of the motor in foolish ways. They ground metal against metal; that was their fault. And they also ground metal against ether, or something of that kind; but that also was their fault, it was not the fault of the motor regarded as a converter of the electric energy supplied to it into mechanical energy.

Mr. A. T. SNELL, in reply, said his primary object in writing the Paper was to elicit discussion, and he did not think he had failed, for both his mathematics and his practical reasoning and results had certainly been handled quite as roughly as he wished them to be. The debate had given them some very important and fresh data, which would set them all thinking, and would, perhaps, enable those who were practical men to make better machines in the future. He had also a second object—that was to bring before the Association a new method of designing, and that is that the motor should be designed primarily with reference to the torque, and not with reference to the horse-power. He regretted that this point had been missed in the discussion, and that the debate had rather turned upon the reversibility of the dynamo. His mathematics all through were intended to be of a practical character rather than strictly correct according to the Cambridge view. He fully agreed with Prof. Ayrton that mathematically the equations in the Paper would not stand; but to practical men, with all deference to Prof. Ayrton, *this* equation for the E.M.F. was of more importance than the elaborate analysis which Prof. Ayrton had put on the board, for the simple reason that they could use the one but could not use the other. The constants are absolutely indeterminate for ordinary practical men; but they could make a motor, and could determine the three quantities in his equation, and they then had all they wanted. It was not of so much importance to them to know whether they lost most of their energy by means of Foucault current, hysteresis, or by friction in the journals, as to know what was the total quantity of energy which was lost. He had got that in this diagram (p. 314, *The Electrician*). That gave him exactly the loss he had in the wire, and the losses other than $C^2\,R$. He was under the impression that *this* term, $\frac{\text{B.H.P. } 746}{n\,c}$, did not appear in Prof. Ayrton's Paper; but he was pleased to hear that he had been forestalled in that. As to Prof. Ayrton's remarks upon the design of motors with reference to their working, there was a certain current which a motor would work at without undue heating. That must be primarily determined. With that current they could do a definite number of foot-pounds per revolution. If the motor was designed, say, to run at 100 volts, and it required only 80 volts, it was of no great importance beyond the fact that one does not get quite as much horse-power out of it. But if, to do the work for which it is intended, it has to run at a higher current, it is absolutely useless, because it will seriously heat. In the dynamo, as a rule, it is chiefly necessary to look to the number of volts. One did not care so much about the number of amperes the machine would give. Mr. Esson had brought forward very strong reasons in favour of the opposite side of the main question; but that gentleman must have overlooked certain parts of the Paper, particularly in the commencement, in which it was distinctly stated that with large dynamos used as motors the same results would not be obtained as when small motors were used as dynamos. Almost all the experiments mentioned in the Paper were made with machines which had been especially designed with reference to their work as motors and not as dynamos. He had, however, made a special experiment a few days ago with a machine that was specially designed as a dynamo. He had placed upon the board a well-known equation, $E = K\,W_a\,N_t\,A$, which gave the internal E.M.F. in terms of a constant, the number of turns of wire, the cross-section of the armature, and the value of the magnetism per square inch. The number of turns of wire was 576, the cross-section of the armature 59in., and the internal E.M.F.s were severally 381·2 and 302·8 volts. On making the calculation it would be found that the value of the induction in the dynamo was 14, but in the motor it was 14·9. Where did the extra magnetism come from? If the views of Prof. Ayrton and himself did not account for the extra magnetism, he was fairly at a loss to account for it. He had unfortunately no mathematical data to prove where this increase of magnetism is gained, but that it does exist he was sure, and the experiments that Prof. Ayrton had made with the assistance of the old students during the last few days with one of the Immisch motors fully confirmed the experiments he himself had made within the last 3 or 4 years (hear, hear). He would have raised the magnetic density if he could have done so, but at the time he had not got the steam power to do it. Prof. Ayrton had referred to the self-induction in the motor tending to increase the lead in the dynamo and to decrease the lead in the motor. It was necessary to explain that the lead in a motor was less than the lead in a dynamo, and the difference in machines of the Manchester type was oftentimes very marked. Frequently in the dynamo there would be a lead of 30 degrees, whereas in the motor there would not be a lead of more than 5 degrees. He was inclined to explain that in this way. It was a very rough explanation, but, unfortunately, it was impossible to get inside the armature, and we do not really know how the lines of force are distributed. *(Illustrating on the black board.)* Let this be a Manchester field, with a ring armature put in it, the brushes being practically on a horizontal line, so that there is no lead. In the motor the lines of force do not pass straight through the armature, but they pass somewhat as shown in the diagram, and the result is that the attraction is greater than the repulsion—the pole of the field, in fact, is very near to the pole of the armature. The resultant pole is always ahead of the brush. The result is that in a motor, although we have a slightly negative lead as regards the position of the brush, yet the resultant pole in the armature itself may be ahead of the horizontal line, and may, apparently, be actually positive. There may thus be a motor-armature strengthening the field, although the brushes themselves stand, perhaps, with a negative lead of 5 degrees. He did not think there was any mathematical proof of this; he had tried very hard in various ways, but he could not substantiate any theory on the subject. The difficulty arose from the fact that the position of the resultant pole varies with every change in the current. If the field, for instance, is increased very much the pole will probably be very far forward, and right underneath the corner of the field; but if the current is decreased the chances are that it will go back, and *vice versâ*. Prof. Ayrton was also kind enough to call attention to an oversight in the Paper in the expression put down for the torque. The equation was really in C.-G.-S. units, and was quite correct as it stood. He thought Prof. Ayrton would grant that. At any rate he thought it appeared in all the text-books, so that if the Paper

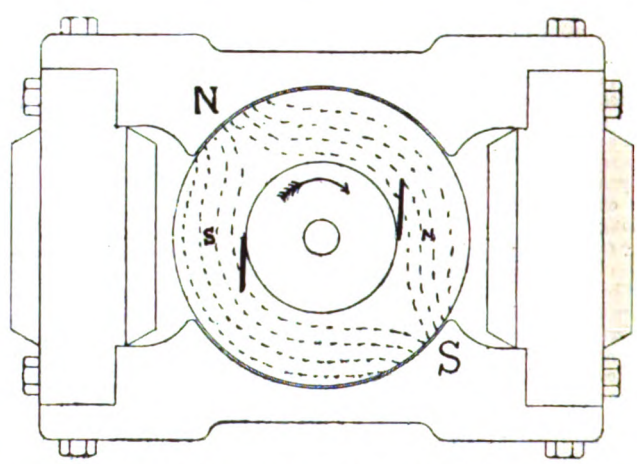

Diagram showing probable position of resultant field in a motor with zero lead

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here was wrong the text-books also were wrong. All through the Paper he had been reasoning in foot-pounds, amperes, and Kapp lines. He ought, therefore, to have put the proper constant in ; but Dr. Walmsley had been kind enough to calculate it, and he would put it on the board.

$$T = \frac{Z_a C_a N_t}{2\pi} \times \cdot 00004432.$$

where T = lb ft.
Z_a = Kapp lines (total No.)
C^a = amperes.
N_t = total No. of turns.

It was rather formidable. The torque there was expressed in foot-pounds. He had forgotten what the constant was, but it was a large quantity. If there was any slip in those figures the students could easily verify it for themselves. Another point raised by Prof. Ayrton was why he (Mr. Snell) advised a field relatively stronger as the size of the machine increased. He did that principally as a result of experience. Experience seemed to point to the fact that as a machine got larger it was advantageous to increase the size of the field. He was, however, willing to concede that the principal reason was the question of cost. A large armature was very costly, and as a rule with big machines the question of weight did not enter into the problem very largely, so that it was cheaper to make a big machine with a small armature and a relatively powerful field, than it was to make one with a large armature and a weak field ; but he had no doubt that if it were wanted to make the experiment they could design a 100 horse-power machine practically on the same lines as one of 1 horse-power.

Prof AYRTON : You have no reason except the cost ?

Mr. SNELL replied practically none, with this exception, that the larger the machine the greater the leakage ; the result is that there is a greater difficulty in maintaining a given concentration of magnetism in the armature. Supposing they wanted to obtain 16,000 C.-G.-S. units in the armature, they could not with the same proportionate field do it ; they would have to increase it a trifle. The increase in a 50 horse-power machine might be probably 10 per cent. over what it would be in the case of a 1 or 2 horse-power machine. He could state this most distinctly, that in all cases where a dynamo and a motor have to be designed with a given armature, a very much smaller field can be used for the motor than for the dynamo. Probably if they could thoroughly analyse the very important equations put upon the board by Prof. Ayrton, they would find the value of the constants ; but the matter was practically an extremely difficult one, and that was why he had been led to use equations of a practical character rather than strictly mathematical ones. He would like to say a few words with reference to the use of the quantity $\frac{\text{B.H.P. } 746}{n\ c}$ before sitting down. It really was an E.M.F. ; that could be seen at once. The B.H.P. multipled by 746 gave the total quantity of watts. It was not known what E.M.F. was there at any time, but the current was known. If they divided by the current they must have a quantity left which is of the order of volts, and that he would prefer to call the *effective* E.M.F. of the motor. That in practice was what one wanted. The theoretical back E.M.F., namely (E – C R), was not of so much importance as the actual effective number of volts ; if they had the latter they had a measure of the efficiency of the machine. He thanked Mr. Reckenzaun for his remarks. He was pleased to hear that Mr. Reckenzaun had found that a dynamo in a given case required 60 per cent. more speed to make the same E.M.F. with the same current as it did when run as a motor. This thoroughly bore out the results of his own experience. With regard to efficiency, the curves (*The Electrician*, Jan. 8, p. 312) were taken from a by no means efficient machine. The maximum horse-power was got from a point where the efficiency was low. With a well-designed machine a large variation of the load did not have a very great effect on the efficiency. He could vary the output by probably 30 or 40 per cent. on either side without obtaining any very great difference of efficiency. They could notice how very steep the curve was on the rising limb. If the load were varied by a very small amount when working on this side of the curve we should get down to one-half the efficiency. He thought they would see that clearly on reference to the curves given in the Paper. He hoped before long to have an opportunity of putting before the Association what he might call curves from a normal Immisch motor (applause).

On the motion of the PRESIDENT a cordial vote of thanks was awarded to Mr. Snell for his Paper, and the proceedings then terminated.

"MODERN VIEWS OF ELECTRICITY."

The following paragraphs, which form the conclusion of the remarkable series of articles under the above title, by Dr. Oliver Lodge, are reprinted (by permission) from *Nature*, of January 31 :—

Conclusion.

"Conclusion" is an absurd word to write at the present time, when the whole subject is astir with life, and when every month seems to bring out some fresh aspect, to develop more clearly some already glimpsed truth. The only proper conclusion to a book dealing with electricity at the present time is to herald the advent of the very latest discoveries, and to prepare the minds of readers for more.

Referring back to Part IV., Vol. XXXVIII., p. 418, we spoke confidently of a radiation being excited by electric oscillations, a radiation which travelled at the same rate as light, which is reflected and refracted according to the same laws, and which, in fact, is identical with the radiation able to affect our retina, except in the one matter of wave length. Such a radiation has now been definitely obtained and examined by Dr. Hertz, of Karlsruhe, and in the last month of last year, Prof. von Helmholtz communicated to the Physical Society of Berlin an account of Dr. Hertz's latest researches. The step in advance which has enabled Dr. Hertz to do easily that which others have long wished to do, has been the invention of a suitable receiver. Light when it falls on a conductor excites first electric currents and then heat. The secondary minute effect was what we had thought of looking for, but Dr. Hertz has boldly taken the bull by the horns, looked for the direct electric effect, and found it manifesting itself in the beautifully simple form of microscopic sparks.

He takes a brass cylinder some inch or two in diameter, and a foot or so long, divided into two halves, with a small sparking interval between, and by connecting the halves to the terminals of a small coil, every spark of the coil causes the charge in the cylinder to surge to and fro about five hundred million times a second, and disturb the ether in a manner precisely equivalent to a diverging beam of plane-polarised light with waves about twice the length of the cylinder.

The radiation so emitted can be reflected by plane conducting surfaces, and it can be concentrated by metallic parabolic mirrors, the mirror ordinarily used being a large parabolic cylinder of sheet zinc, with the electric oscillator situate along its focal line. By this means the effect of the wave could be felt at a fair distance, the receiver consisting of a synchronised conductor with a microscopic spark gap, across which the secondary induced sparks were watched for. By using a second mirror like the first to catch the parallel rays and reconverge them to a focus, the effect could be appreciated at a distance of 20 yards. If the receiving mirror were rotated through a right angle, it lost its converging power on this particular light.

Apertures in a series of interposed screens proved that the radiations travelled in straight lines (roughly speaking, of course).

A gridiron of metallic wires is transparent to the waves when arranged with the length perpendicular to the electric oscillations, but it reflects them when rotated through a right angle, so that the oscillations take place along the conducting wires ; thus representing a kind of analyser proving the existence of polarised light. The receiver itself acted as analyser, however, for if rotated much it failed to feel the disturbance.

Conducting sheets, even thin ones, were very opaque to the electrical radiation ; but non-conducting obstacles, even such as dry wood, interrupt it very little, and Dr. Hertz remarks, "not without wonder," that the door separating the room containing the source of radiation from that containing the detecting receiver might be shut without intercepting the communication. The secondary sparks were still observed.

But the most crucial test yet applied is that of refraction. A great prism of pitch was made, its faces more than a yard square, and its refracting angle about 30deg. This being interposed in the path of the electric rays, they were lost to the receiver until it was shifted considerably. Adjusting it till its sparks were again at a maximum, it was found that the rays had been bent by the pitch prism, when set symmetrically, some 22deg. out of their original course, and hence that the pitch had an index of refraction for these 2ft. waves about 1·7.

These are great experiments. As I write, they are but a month old, and they are manifestly only a beginning. They are very simple ; I have repeated some of them already. They seem likely to settle many doubtful points. There has been a long standing controversy in optics, nearly as old as the century, as to whether the direction of the vibrations was in, or was perpendicular to, the plane of polarisation ; in other words, whether it was the elasticity or the density of the ether which varied in dense media ; or in Maxwell's theory, whether it was the electro-magnetic or the electrostatic disturbance that coincided with that plane. This point has, indeed, by the exertion of extraordinary power, been almost settled already, through the consideration of common optical experiments ; but now that we are able electrically to produce radiation with a full knowledge of what we are doing, of its directions of vibration and all about it, the complete solution of this and of many another recondite optical problem may be expected during the next decade to drop simply and easily into our hands.

We have now a real undulatory theory of light, no longer based on analogy with sound, and its inception and early development are among the most tremendous of the many achievements of the latter half of the nineteenth century.

In 1865 Maxwell started his theory of light. Before the close of 1888 it is utterly and completely verified. Its full development is only a question of time, and labour, and skill. The whole domain of optics is now annexed to electricity, which has thus become an imperial science.

Oliver J. Lodge.

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A "UNIVERSAL" GALVANOMETER.*

BY DR. A. D'ARSONVAL.

The instrument which I am about to describe was devised specially to meet the requirements of physiological research. It is a tangent galvanometer of the Wiedemann pattern, and embodies the numerous modifications of which practical experience has taught me the value. It is dead-beat or ballistic as required, and it can be changed into a Nobili astatic, a plain Thomson, or a differential Thomson galvanometer by a simple alteration of the magnetic equipment. It has therefore the great merit of meeting all requirements in a single instrument of great precision and comparatively low price. One important point consists in the complete separation of the coils and the part of the instrument carrying the needle and damping apparatus, which greatly facilitates alterations and transport. I will now describe the two portions separately.

FIXED PART.—Fig. 1 represents the galvanometer in perspective, Fig. 2 being a section through the moving parts of the instrument. On the circular plate P there is a graduated rod, R, carrying the coil frames. This plate is supported on three screws, only two of which, V V′, are adjustable. The line joining V V′ is perpendicular to R, so that it is only necessary to place these two screws in the magnetic meridian in order to have the instrument properly adjusted once for all. Two split pieces, E E′, slide on the rod R

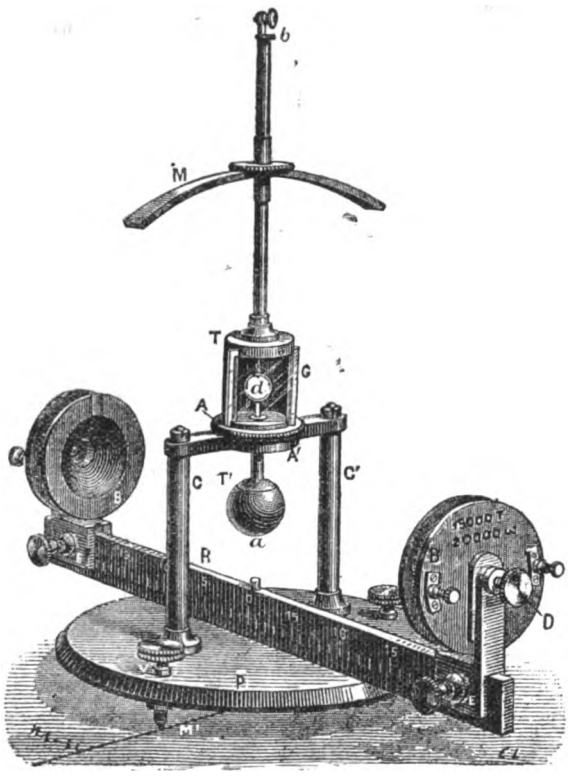

FIG. 1.

and they are provided with screws to fix them in whatever position required. The upper part of E E′ is furnished with a screw, D, which keeps the coils tight. The bobbins are hollowed out in order to receive the ball of the damping apparatus *a*. Each bobbin is provided with two terminal screws, and on it is written the number of turns of wire and its resistance in ohms. The changing of these bobbins is an easy matter. Each apparatus carries two sets—one of 150 turns and ·4 ohm resistance, the other of 15,000 turns and 20,000 ohms resistance for ballastic purposes and E.M.F. measurements. On either side of R rises a circular support, C and C′, joined at the top by a cross-piece, A′. This part of the apparatus is of copper, and always remains the same.

MOVING PARTS.—The moving parts (magnet and damping arrangement) also form a complete whole. The cylindrical box T is surmounted by a metal tube, carrying the compensating magnet M, and provided with a screw head, *b*, on which there is a small windlass upon which the cocoon fibre is wound. The lower part A is provided with a rim and just fits into the ring A′. This lower part ends in a small tube, T′, which terminates in a screw head, upon which the copper damper, A, is screwed. The drum T has an opening, G, fitted with glass, which is slightly oblique, to avoid the reflections which are so troublesome when the glass and mirror are parallel. The cocoon fibre, which starts from the windlass, terminates in a small hook, *c*, from which the mirror is suspended. The simple magnetic arrangement consists of a powerful little horseshoe magnet, weighing 1·5 to 2 grammes, and able to support 62 times its own weight. The magnet is screwed to a wire, which fits by friction in a socket in the frame of the mirror *d*. The mirror can therefore be set in any azimuth. The damper consists of a copper ball, *a*, which screws on to T′; it is pierced by a cylindrical hole, in which the magnet turns, with 1 millimetre play all round. As the sphere is 4 centimetres in diameter, while the external diameter of the magnet is only 1 centimetre, the damping effect is considerable, even without making the instrument astatic, and, moreover, it remains the same in every azimuth. It is easy to see that there is no difficulty in moving the damper without touching the needle, and replacing it by a simple thin brass ball, by a less powerful cylindrical damper, *e*, or by a variable damper, *f*. The variable damper consists of a ring of copper which slides inside a split cylinder by means of two studs, and a ring which fits on to the external threads of the cylinder, as shown in *f*. According as the magnet is more or less surrounded by the damper, the damping effect is altered. One can also use a liquid damper consisting of a thin brass ball filled preferably with ordinary petroleum. If the directing magnet M is taken off, we simply have a tangent instrument. To make it an astatic instrument of the Haüy type, it is only necessary to replace M at the proper height in the ordinary manner. If it is desired to use the galvanometer as an astatic

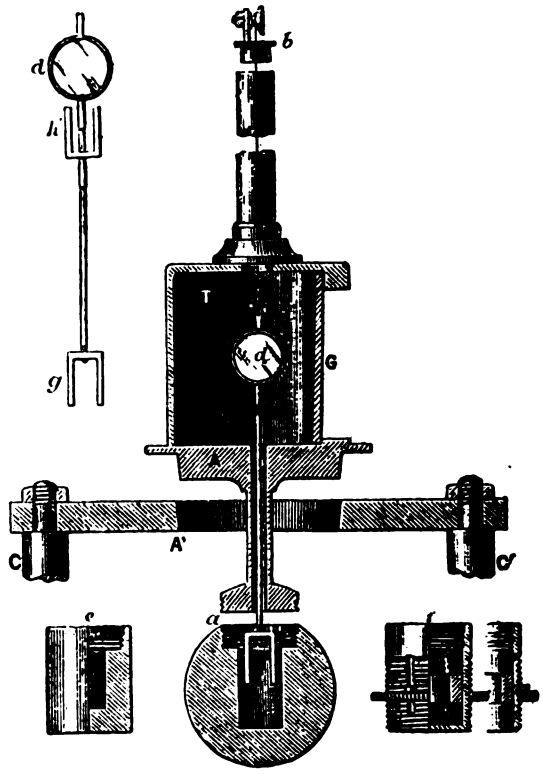

FIG. 2.

galvanometer of the Nobili pattern, we merely screw on a second magnet, *h*, similar to *g*, taking care to oppose the poles. Finally, the whole magnetic apparatus can be taken out and replaced by a single or double Thomson equipment, employing if desired the liquid damper, which is very efficacious in this case. It is extremely easy to change the cocoon fibre by merely unhooking the mirror and taking off the top of the tube. The windlass is very small, so that the directing magnet M can be taken off or put on without altering the suspension. When the instrument is turned into a Haüy astatic galvanometer, the damping effect is so powerful that it is necessary to diminish it by replacing the ball *a*, either by the cylindrical damper *e*, or by the variable damper *f*. The readings are taken either off a transparent scale or off the micrometer scale, which I have previously described. In the latter case the sensitiveness becomes 25 times greater for the same angle of deflection. This method of reading is very valuable when the instrument is used as a tangent galvanometer. In another article I shall describe the necessary alterations for the measurement of E.M.F., resistance, capacity and temperature, &c., as well as the optical method which permits of a large audience witnessing these readings. It is on account of the multiplicity of uses to which this instrument can be put, that I have called it a universal dead-beat galvanometer. The successive modifications, which daily experience taught me to be necessary, were carried out in the workshops of M. de Branville, 25, Rue de la Montaigne, Sainte Geneviève.

* Abstracted from *La Lumière Electrique*, January 5, 1889.

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ON THE ELECTRIFICATION OF METALLIC PLATES BY ILLUMINATION WITH THE ELECTRIC LIGHT.*

BY W. HALLWACHS.

The author refers to a previous Paper, in which he showed that illuminated plates receive thereby an electrostatic charge (Wied. *Ann.*, XXXIII., p. 301). These charges are of the same order as those produced by the contact potential difference between two metals.

To test this charge he takes a circular metallic plate, 8 centimetres in diameter, and suspends it by an insulated wire inside a cylindrical vessel, whose axis lies horizontally. This cylinder is made of sheet iron, and is 50 centimetres long and 37 centimetres diameter. The cylinder was rusty and stood on a stand leading to earth. The part electrically connected to the stand was well cleaned. The wire suspending the plate led to a Hankel electrometer, and to prevent its receiving extraneous charges it was protected by brass tubes connected to earth and surrounding it.

The electrometer was of small capacity. In one of the (vertical) ends of the cylinder was a centrally placed hole covered by a brass wire gauze, and through this the light came which fell on the plate. The hole was of the same size as the plate. The light was 45 centimetres from the gauze, and was on the axis of the cylinder and suspended plate. The gauze protected the suspended plate from the direct action of the current in the arc lamp. This effect could be detected if the gauze was removed.

The cylindrical screen was of rusty sheet iron in order that its contact potential should be always negative to that of the suspended metal plate. By this means the effect of illumination could always be distinguished. For if the plate had been negative to the cylinder, the illumination might possibly increase the potential of the plate by driving away its negative charge; but if the plate is positively electrified, and is then illuminated, we should only expect a rise in potential if + electricity were generated by illumination. The contact E.M.F. between rusty iron and clean zinc is $-1{\cdot}2$ volt.

If the rays of the electric lamp were screened by mica the illumination had no effect on the plate; but when they passed through a plate of isinglass much thicker than the previous mica one the electrometer showed a gradually increasing positive charge; the mica plate on being inserted checked the increase of the charge. The rise of potential cannot, therefore, be due to inductive action nor to temperature effects. It must be purely an effect due to illumination.

The metals tried were zinc, brass and aluminium. The illumination always charged them positively, but only if they had clean surfaces. Dirty plates showed no effect.

The effect of any illumination is to decrease the magnitude of the maximum positive charge which any subsequent illumination can produce. The plate becomes fatigued, as it were, by constant illumination. The magnitude of the *maximum* rise in potential was for zinc over a volt, for brass about a volt, and for aluminium $0{\cdot}5$ volt.

* Wied. *Ann.*, N.F. XXXIV., p. 731. (Abstract made by Dr. J. L. Howard, Demonstrator in Physics at University College, Liverpool.)

LEGAL INTELLIGENCE.

In re Gaulard and Gibbs' Patent.

COURT OF APPEAL.—TUESDAY, JANUARY 22.

Mr. MOULTON then addressed the Court on behalf of the respondents. He said Mr. Aston attempted to escape from his enemies very much as the cuttle-fish did—not by proving his case was right, but by making it almost impossible to see through the argument, which was inconsistent and obscure. There had never been any adherence to any one interpretation, and the very thing which had enabled Mr. Aston to do that without instant detection was the fact that the patent did not define the invention in a way which would give one a clear idea of it. That very fault was most fatal to a patent. (The learned counsel then exhibited the machine, which was in the court below when Sir William Thomson gave evidence.) The high tension could not form in any way the basis of a patent, and it was not novel. That there must be a proportionate pressure to send the required current through the wire was perfecly well known, but here was not one single atom of information about it in the specification. It was claimed that a stepdown was part of the patent. It was suggested that the mention of light and motive-power made it a specified essential of the patent that the secondary should be in low tension. If it was essential to the patent, it was not so stated in it, and the patent must be bad. He asked the witnesses, until he was tired of doing it, "Can you point to a single word in this specification, provisional or complete, which indicates any special tension in the secondary?" and every one of them said he could not. According to Gaulard and Gibbs they might have taken out a patent in the very same words as Jablochkoff, and said it was novel. Why? Because in Jablochkoff's time the fashionable lamp was a high-tension one, now it was low tension. No electrician spoke with the same authority all over the world as Sir William Thomson, and he gave his evidence with the most remarkable impartiality. He said there was nothing in the specification to indicate that it was necessary to use low tension. Mr. Aston said that a special generator was essential to the combination; and there was no attempt made by any witness on the other side to show that it would be novel if there was not a special form of generator. The things that were done were just as much Jablochkoff, and Edwards and Normandy, and Marcel Deprez perhaps more than anybody, as they were Gaulard and Gibbs. Jablochkoff's system was most clearly set out in a manner which would have conveyed far more information than Gaulard and Gibbs did, because it was conveyed without any tinge of error, and in a way which would excite the respect and attention of electricians, instead of being mixed up with matter which would lead them to reject it. Jablochkoff's was practically known in England, and yet it had never been tested, and it was one or two years before Gaulard and Gibbs came into practice. That there was this interval before being used did not make Gaulard and Gibbs invalid, nor did Jablochkoff's not being used make it any the less part of the knowledge of the world.

To support the patent, two things were necessary—the claim must make it clear that the generator was of special form, and it must be shown that they had told the world what was that special form. The patentee had defined two induction coils perfectly, down to the last screw, but he did not define any class. He hoped their lordships would protect them from this—that a man, by describing the numerical dimensions of an instrument which embodied his invention, without stating what were the essentials of that invention, would be able to put any interpretation on those numerical descriptions, so as to make them include any invention that he liked, according to the events which happened after his patent. He defied anybody reading the specification to find out the special class of the generator.

If the public were supposed to look at the anticipations with the same instructed eyes with which they were supposed to look at the specification, it would be seen that over and over again this was anticipated. But above all he took Jablochkoff; first of all because Jablochkoff was entitled to the merit of this idea of distribution. It was Jablochkoff who pointed out that you could give a man a different kind of current from that supplied to his neighbour. It was admitted that Jablochkoff might have worked with high tension, although he did not mention which tension; he left that to the electrical engineer. It was published by Jablochkoff in a way in which it could be used with any tension, with any number, and to any distance. Then how could it be said that after Jablochkoff there was anything to publish? Jablochkoff did not limit the tension in any way; he took a current that gave him his result. The advantage of driving to a long distance with high-tension currents, on the evidence of the patentees themselves, was common knowledge. Dr. Fleeming Jenkin, in his report, said the appellants' system was founded "on the well-known principle that it is economical to use high-tension currents in driving to a distance." In trying to show the novelty of Gaulard and Gibbs' system, Mr. Aston had referred to Sir William Thomson's speech, where he pointed out that if you want to distribute electricity from Niagara it must be turned to a high-tension current, and distributed at a high tension for the very purpose of sending it to a distance in the form of a high-tension current. Economically there is no difference between a high tension with alternating currents and a high tension with direct currents. When people obtained provisional specifications before going to the expense of complete specifications, they made careful inquiries as to previous patents. He consequently had not the slightest doubt that Jablochkoff's patent had stifled a great number of provisional specifications. If Edwards and Normandy had said, "In the face of Jablochkoff can we get a patent for general distribution by secondary generators?" a prudent adviser would have said, "Certainly you cannot; you can only claim for some detailed improvement in the means."

Mr. ASTON then replied on behalf of the appellants, his final argument occupying nearly two days.

At the conclusion of the learned counsel's argument their lordships reserved judgment. Their lordships also intimated that the arguments might have been shortened, Lord Justice Lindley observing that four days would have been ample instead of the ten days occupied in the hearing.

Watt v. Maxim-Weston Electric Light Company.

In the Chancery Division of the High Court of Justice on Friday last, before Mr. Justice North,

Mr. HIGGINS, Q.C., moved on behalf of the plaintiff, Mr. Hugh Watt, for an interim injunction to restrain the defendants until the trial of the action or further order from carrying into effect a scheme of reconstruction of the defendant company as resolved upon by certain resolutions dated December 21, 1888, and January 7, 1889, and also from entering into and carrying into effect the agreement referred to in the scheme; or, in the alternative, for an injunction to restrain the defendants, the letters patent, and assets of the company in pursuance of the scheme until reasonable security for the amounts payable to the plaintiff should have been provided.

Mr. COZENS HARDY, Q.C., said the defendants were prepared to maintain that the proposed reconstruction was regular, and that the security given to dissentient shareholders was ample; but at the same time, the defendants were willing to deposit in the joint names of the solicitors a sum which would satisfy the plaintiff.

Mr. JUSTICE NORTH directed the motion to stand till the trial of the action, the costs of the motion to be costs in the action.

BOOKS, &c., RECEIVED.

"*Journal* of the Society of Telegraph-Engineers and Electricians." Vol. XVII. No. 76.

"Traité Théorique et Pratique d'Électrochimie." By Dr. Donato Tommasi. (Paris: E. Bernard et Cie.)

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *January 26th*, 1889.

An extremely important decision has been rendered by the United States Supreme Court in the patent case of the Bate Refrigerating Company against Geo. H. Hammond and Co., which has a direct bearing on electric light interests in this country. As you are aware, it has been held by a number of litigants for some time, and they have been sustained in their views by some of the United States Circuit Courts, that an American patent was limited by the duration of any similar foreign patent which had been previously secured; and this principle has had the practical effect of bringing under suspicion of invalidity a large number of early electrical patents, especially those of Mr. Edison. The Edison Company has therefore had particular interest in the issue of the present suit, and has taken an active part in fighting it through. One of the grounds upon which the Bate Refrigerating Company had lost its suit against the Hammond Company in the Lower Court was that the patentee had taken out in Canada a patent for the same invention prior to the issue of the United States patent, the shorter term of which Canada patent had expired, so that, therefore, the United States patent was also at an end. The Court says: "The holding of this Court is that, inasmuch as this Canada Act providing for this extension was in force when the United States patent was applied for, and when the United States patent was issued, and under the provisions of the Canada Statute, the extension was a matter of right, at the option of the patentee, on his payment of a specified fee, and inasmuch as the fifteen years' term of the Canada patent was, on the facts of the case, continuous and without interruption, the United States patent does not, under the terms of Section 4,887 Revised Statutes, expire before the end of the fifteen years' duration of the Canada patent. We further hold that it was not necessary to the validity of this United States patent that it should have been limited in duration on its face to the duration of the Canada patent, but it is to be so limited by the Courts on evidence in pais, so as to expire at the same time with the Canada patent, that is with the same time as the extension, not running, however, more than 17 years. This is sufficient to dispose of the case. Another question was earnestly discussed in the case by both parties, but as we do not find it necessary to the decision of the case we do not find it necessary to determine the question, nor do we regard it as proper to do so. That question was this: It was contended by the appellant, as a further ground for reversing the decree, that the words of Section 4,887, 'first patented, or caused to be patented, in a foreign country,' do not mean before issuing or date of the grant of the United States patent, but means patented or caused to be patented before the date of the application for the United States patent. We do not consider or pass upon that question." As far as I understand this decision, it affects at least twelve of the Edison patents, including such fundamental ones as those on the broad invention of the filament lamp; the use of the high resistance enclosed conductor in a vacuum chamber entirely of glass; the use of a lamp removable from the socket, and the making of the enclosed chamber of the lamp in two parts fused together; the perfection of the carbon filament by getting rid of the occluded gases by the heat of the current; the making the filament of bamboo or other fibrous material, having the fibres parallel through the length of the filament, and the broad feeder patent. This decision is also reported to have a revivifying influence on other electrical patents, such as that of Mr. Brush on compound winding. We shall probably know a little more about this, and when the full text of the decision is given out the parties to the various litigations will see how they stand. At present the decision is the main theme of conversation in electrical circles, and in the Edison camp has been hailed with the greatest delight. Naturally those who have been fighting against the Edison claims point to the fact that the patents have still to be confirmed strictly on their merits, and that this decision simply affects the question of the effect of a foreign patent upon a United States patent under certain conditions. There is a feeling of satisfaction, however, at seeing the Supreme Court once more pronounce in support of patents, especially in a case where the inventor was so liable to suffer from no fault of his own, and really because he was anxious to proclaim to the world at large the fact of another triumph of American genius and skill.

Another important event in the electrical field this week has been the consummation of an arrangement or agreement between the Westinghouse Electric Company and the United States Electric Light Company. This does not appear to be so much a consolidation as a combination of interests, or, to use a much-abused word, a form of "trust." It is provided that the interests of the two companies shall be conducted hereafter for their mutual benefit, not only in the production of apparatus, but in the offensive and defensive use of their patents. It is said that the new combination has control of several hundred patents, and will represent a united capital of about ten millions of dollars. The United States Electric Lighting Company is, as you are aware, one of the oldest electrical concerns in the country, as the Westinghouse is one of the youngest. It has done a large amount of work, though perhaps not as much as might have been expected from its early organisation, and from its enjoyment of the assistance of such well-known men as Maxim, Moses G. Farmer, and Edward Weston. The Westinghouse Company is evidently bent on adding to the number of its alliances and strengthening itself in every possible way. In addition to the new arrangement with the United States Company, it has control of the Waterhouse arc lighting system and of the Tesla alternating-current motor, as well of the Sawyer-Man incandescent lamp. It will be seen that this makes a strong combination. It remains to be seen whether the companies concerned can hold together for any length of time.

I have advised you from time to time of the various agitations started in different parts of the country for the reduction of telephone rates. So far none of these agitations have been attended with any marked results, beneficial or otherwise, except in Indiana, where the legislators certainly did succeed in cutting off their nose to spite their face, and managed to deprive many of their constituents of the use of the instrument that has now become so necessary in local communication. The ill success of these serious movements might well have discouraged any attempts at new ones, at least until the patents run out; but I suppose that, like the poor, the telephone agitator will be always with us. He has resumed the work in Missouri, where there is a Bill before the Legislature, and the movement has also been resumed in Ohio, where it is proposed to cut down telephone rates to $3 a month. In this State a bill has just been presented to the Legislature at Albany, providing that the subscription in cities of 500,000 inhabitants and over shall not exceed $6 per month, and in all other places $3 per month. It may have struck you as peculiar that a division should have been made with regard to cities "of 500,000 inhabitants and over." The object of this neat little clause is to get round the provision in our State Constitution, that there shall be no special legislation of this nature affecting particular localities. Of course, as will be seen, this is not special legislation of an obnoxious character against which the Constitutional provision is made; but as New York and Brooklyn are the only two cities in the State that are over 500,000 inhabitants, there is no need to name them; and the little bill, should it become law, would have just the same effect as though they had been specifically mentioned.

Some interesting work is being done at the present time by the Pullman Palace Car Company in connection with lighting up trains by electricity. This company has been at work in that direction for some years past, and more recently has formed an electric department of its own at its big works near Chicago. The line of work upon which the company is experimenting at the present time is a little bit different, perhaps, from that which we have heretofore seen. If I am not mistaken the two methods hitherto followed in this country were those of charging a number of cells at the termini of the road, and then exchanging them, or else connecting up the generator with the axles of the baggage car

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and thus charging the cells on the train whenever the train is running. The first method is the only one that has had practical utilisation worthy of mention. The Pullman Palace Car Company, however, in making up their special trains, such as that, for instance, which has just been put on to run three times a week between this city and Jacksonville, Fla., has placed on one of the cars a complete plant, which takes its steam from the locomotive. This plant comprises a small 3-cylinder Brotherhood engine, an Eickemeyer "iron-clad" dynamo, and 32 cells of electrical Accumulator (E.P.S.) Company's battery. The exhaust steam from the Brotherhood engine is used for heating the cars. This plant is economical of space, not occuping a greater floor area than 6ft. by 3ft.; but I have been given to understand that the engine, in spite of many merits, is not altogether satisfactory, the noise made being a very objectionable feature, especially in "vestibule" trains, which are practically a single unit. The racket of the engine whenever the train stops is quite disagreeable. Hence, there is still room for improvement, but it is said that the dynamo answers its purpose admirably.

NOTES FROM GERMANY.

(FROM OUR CORRESPONDENT.)

The past year has witnessed a great advance in the application of electricity, especially as regards electric lighting from central stations. Of course, the capital of the German Empire is far ahead in this respect. The use of electric light in the busy centre of Berlin has increased in an undreamt of manner. Five years ago the Allgemeine Electricitätsgesellschaft started the first small plant in Friedrich-strasse with a capacity of 2,000 16 candle-power lamps. Later on, when the company was allowed to lay cables along and below the streets, the second station was built in Markgrafen-strasse, where, to save space, the boilers had to be placed above the engines. The station in Markgrafen-strasse had six engines of 170 horse-power each and 18 dynamos, driven through belting. The station in Mauer-strasse, which was erected soon after that in Markgrafen-strasse, is very similar, and had originally three engines of 170 horse-power. This latter station was enlarged in 1887 by three further engines of 170 horse-power each, so that in the fall of that year these two stations possessed together 2,400 horse-power. This motive power being fully used in the beginning of 1888, the several stations were much enlarged. The station in Markgrafen-strasse received an addition of 1,200 horse-power, and was joined to the station in Mauer-strasse, whence the arc lamps that light the "Unter-den-Linden" are supplied with current. These two stations have now 3,900 horse-power available. In a short time two further stations in the Spandauer and the Dorotheen-strasse will be erected, each of which is intended to feed 20,000 incandescent lamps. Preparations have also been made to further enlarge the existing stations, so that the Berliner Electricitätswerke will dispose shortly of no less than 14,000 horse-power. Great economies have also been effected in working. The cables of the three stations in Markgrafen, Mauer, and Friedrich-strasse have been united, and thus it has been rendered possible to throw the expensive daily service during winter, and the total supply during summer, upon one station only. It may be interesting to state that in these plants vertical 1,000 horse-power engines, with double cylinders, are in use. The gas journals assure us that the extent to which electricity is used at present in Berlin is unequalled in Europe. Whether this be true or not, it is certain that in some districts of the German capital the demand for light has more than doubled, and that in addition there is a growing demand for electrical transmission of power.

Passing from the metropolis to the old city of Nuremberg, I may say that the Messrs. Schuckert have erected and started the plants for the Hamburg, Bremen, Luebeck, and Barmen stations. The free port of Hamburg has been provided with a station having a 5,000 16 candle-power lamp capacity, in addition to 33 12-ampere arc lamps. The plant comprises six dynamos for the incandescent lamps with a capacity of 360,000 watts, and six dynamos for the arcs with a total output of 36,000 watts. These dynamos are driven by belts from a common shafting. Four engines are used, three of which are 138 horse-power engines, whilst the fourth gives 50 horse-power. The larger engines are horizontal compound condensing engines, furnished by the Saechsische Maschinenfabrik at Chemnitz. The cylinders are 16 and 24 inches diameter respectively, the stroke is 32 inches, and the number of revolutions is 100 per minute. The normal output amounts to 138 horse-power, but it may be increased by change of the cut-off to 222 horse-power. The smaller engine is a horizontal high-pressure expansion engine, with a cylinder of 14½in. in diameter, and a stroke of 28½in., running at 90 revolutions a minute. The engines drive the shafting by means of ropes off the fly wheels, the dynamos being driven by belts. These dynamos are of the well known Schuckert type. The ampere meter for the total amount of current, as well as the rest of the ampere and voltmeters, are Hummel's galvanometers. The large ampere meter consists of a copper bar weighing 10 kilos, whilst the total weight of the movable parts only amounts to 7 grammes. The instrument measures up to 2,500 amperes. The incandescent lamps are divided into 15 circuits, each of which is provided with an automatic tension regulator. The mains are provided with double lead covering, and are laid underground in U-shaped iron boxes. The 33 arc lamps are divided into three circuits. The Bremen plant has a capacity of 2,000 16 candle-power incandescents and 80 12-ampere arcs, an increase of 150 per cent. being anticipated. The arcs and incandescents are run off the same dynamos, for which reason the former are connected two and two in parallel with the glow lamps. The plant comprises four 67,000 watt dynamos, and two 180 horse-power engines. The dynamos are driven directly through belting. The engines are vertical compound condensing machines, the cylinders having a diameter of 15½ and 26¾ inches respectively, with 20-inch stroke. The output at 150 revolutions per minute amounts to 180 effective horse-power, which may be increased by changing the cut-off. Each of the engines has two belt fly wheels of 8½ feet in diameter. The system of distribution is the same as at Hamburg. Most of the arc lamps are fed by special feeders, so that of twelve circuits ten belong to incandescent and two to arc lights. The length of the mains varies between 100 and 1,900 metres; the loss of potential in them at the highest possible output is 15 volts. Every main has two tension wires, and consists of a double lead-covered cable, put either in one of the iron boxes mentioned above or into channels in the quay walls. Other German towns have also built central stations, Elberfeld being the first and Barmen the second town which opened a central station at its own expense. The station at Barmen was started after a great deal of hard and troublesome work. For the present it has to supply 2,000 16-candle-power lamps by means of four dynamos, but it is designed so that it can be easily made to supply 6,000 lamps. The third town was Darmstadt, where the three-wire system has been brought into use; but as long as the service was provisional the lamps were run from the two external wires only. The station supplies the theatre with 2,400 lamps, and a total of about 5,000 lamps. It was built by Siemens and Halske, and the dynamos used are shunt-wound, with internal poles directly coupled on the shaft of Kühn's engines. These small, elegantly-built and beautifully working engines, which run at from 200 to 220 revolutions per minute, are at present very largely used in Germany. Liegnitz, Görlitz, Leipzig, are preparing for central stations. Frankfort-on-Main, whose grand central railway station has been lighted by arcs (incandescent lamps being used only in the waiting rooms), wants to spend about three millions of marks on a central lighting station. Marienthal, the famous Austrian bathing-place near the German frontier, will next season be illuminated by arcs and incandescent lamps. Ganz and Co., of Budapest, will build this station, and supply the town with current by means of their alternating current transformers. Alternating currents are, generally speaking, very little in use in Germany up to the present.

The first number of the *Elektrotechnische Zeitschrift* contains a Paper read before the Elektrotechnischer Verein by A. du Bois Raymond, dealing with the difficulties that occur in the transmission of power by alternating currents. The Paper is very ably written, and every possible effort made to prove that continuous current motors are much to be preferred. The author states that a common continuous current motor, whose magnet cores are built up of insulated sheet-iron, will never yield the same output with alternating currents, as the iron grows very hot, the sparking at the brushes increases with increasing output, and, in addition, the output depends upon the difference of potential at the terminals. If we try to improve the result by short-circuiting the armature and sending the alternating current only around the field-magnets, we can reach the same output and efficiency as with a continuous current. But we shall have the same relation between output and potential difference at the terminals as before. Passing to the synchronous type of motors, we find the drawback that the load must always be kept below a certain limit, and that the efficiency increases with decreasing load. The Helios Company has lately patented a device which consists chiefly in coupling an ordinary continuous current motor together with a properly arranged commutator in such a manner that the alternating-current lead into the system is corrected by the revolution of the motor as long as synchronism exists. But this commutation, of course, is accompanied by further losses of energy, and, for an alternating-current of only 70 alternations per second, the motor would have to make 4,200 revolutions per minute in order to produce synchronism. Even in the Tesla motor the author finds many disadvantages. The magnetic circuit, he says, cannot be arranged so advantageously as in a continuous current motor, two windings having to be placed between armature and field magnets; and the work used to reverse the magnetism necessarily far surpasses that

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used in a continuous current motor with the same output. This interesting and well-written Paper concludes with the pessimistic question, "Will time be able to overcome all these difficulties?"

SCANDINAVIAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

The Swedish manufactory for incandescent electric lamps in Stockholm, belonging to the firm of R. W. Strekleuert and Co., will be again extended, the works having already been taken in hand. The annual production will thereby be raised to a maximum of 1,000,000 lamps, and the manufactory thereby becomes the second of its kind, number one being the Edison Company's in America, with a production of about 1,800,000 lamps per year.

In Sweden electric light has recently been introduced in several railway carriages, and it is now also contemplated to adopt this mode of lighting in the mail cars on the Helsingborg-Hessleholm and the West Coast Railway, and will probably soon be generally adopted.

In Stockholm a central station for electric light was opened on Dec. 1st by the Stockholms Elektriske Belgsningsakliebolag. The installation comprises three dynamos from Siemens and Halske, but another will soon be added to this number. Each dynamo has a capacity of 1,000 16-candle incandescent lamps. The Crown Prince of Sweden is at present the largest subscriber.

Several Swedish towns have already adopted, or are about introducing, electric light for the lighting of the streets. At Eskilstima the Corporation has just decided to have the streets of the town lighted by electricity. Luiea, too, is likely soon to be lighted by electricity, and will probably be the most northerly town in the world where this mode of lighting is used.

Even in Copenhagen, where the electric light is very slow in making friends, shops are now beginning to adopt it, and the Corporation has recently sent out an engineer to various countries, so as to get some idea of what folks are doing in other capitals and big towns. A good-sized installation has just been carried out, viz., that of the National Theatre, Restaurant, &c. The engine and boiler rooms are entirely underground; there are two 30 horse-power boilers of De Nayer's safety tubular system, and two engines of 26 horse-power each. There are two of Schuckert's dynamos, and the installation comprises some 28 arc lamps, and 250 incandescent lamps.

Although the installation has cost about £3,300, a considerable saving is reckoned upon, and it is expected that the electric light will cost some £500 less per annum than did the gas. Besides, there is a surplus of electric power, which can be let to the neighbouring shops, &c., so that the "National" installation, in fact, becomes the first, albeit modest, central electric station in Copenhagen.

The number of conversations at the Stockholm General Telephone Company for each year since 1884 is shown in the following table:

1888.	1887.	1886.	1885.	1884.
8 007,282 ...	6,462,548 ...	5,802,063 ...	4,772,760 ...	2,332,082

The number of telephones owned by this Company on November 30th, 1888, was 4,493, against 4,015 the previous year.

Electrical tramways are to be introduced in the town of Sundsvall, in Sweden, the electrical engineers being the well-known firm of Messrs. Thomson-Houston, of Boston. The machine power is to be supplied by a waterfall near the town, so that of course the cost of working will be very small. Should the experiment be successful, other Swedish towns will follow this example, water power being almost everywhere plentiful. This will be the first electrical tramway in Scandinavia.

CORRESPONDENCE.

INDUCTIVE INFLUENCE BETWEEN DISTANT CIRCUITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think it very probable that Mr. F. Higgins (*Electrician*, February 1st, page 378) may be correct in his conclusion that the interference between certain circuits he names is not due to inductive influence.

At the same time I conclude, from the several letters on this subject that have appeared, that it is not generally known that the observable inductive influence of one circuit upon another is not limited to yards, or even hundreds of yards, but extends to miles, scores of miles, perhaps even hundreds of miles, if only suitable means be employed.

The most striking example with which I am acquainted is one of the experiments devised and executed by Mr. A. W. Heaviside in the summer of 1886, viz., conversation per microphone and telephone carried on between two metallic circuits, consisting of squares a quarter mile on each side, a half mile between centres; shortest distance, therefore, a quarter mile between wires of a quarter mile in length. It is not the distance that is here remarkable, but the smallness of the currents in the influencing circuit. (See *Phil. Mag.*, Sept., 1886, p. 273, and Nov., 1886, Postscript to Part IV. of "Self-Induction of Wires.")

I believe that when the details of these experiments are published they may be found not uninteresting.—Yours, &c.,

February 5, 1889. OLIVER HEAVISIDE.

LIGHT WITHOUT HEAT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Owing to the frequent remarks in your editorial and other columns within the last few months upon subjects connected with the obtaining of light without its accompanying heat, and on account of the researches of Profs. Hertz and Lodge, I am induced, as a means of protection, to place before you and the public my own claims upon the subject. It was not expected that the above researches would have been discovered and brought out quite so soon, although matters have been tending in that direction for some time. My work in this field was commenced in the latter part of 1884, and has been continued in one form or another up to the present date. It is quite evident that when an electric current is passed through a filament a part of its energy appears in the form of useful light, and the remainder and larger part in the form of heat. But as light can exist and perform its various luminous, chemical and electrical effects without the aid of heat, the latter, when emitted from the filament, is a total loss of electric energy. I have at present two or three methods, with their modifications, in a more or less completed form, for overcoming this difficulty, and I hope in the near future to bring forth a lamp the illuminating parts of which can be handled with impunity, while the same is giving forth a brilliant and soft light. Perfection will be reached when the filament will remain absolutely cold while under full action. A modified source of electricity is used in some cases with these lamps as well as other sources of energy. The filaments are made in various shapes, some of them not at all resembling those we are accustomed to see, while in a few of the improved lamps none are used. The colour of the light emitted can be varied through the entire spectrum in certain forms of lamps. In his late address Prof. Brackett mentioned the idea of casting polarised rays of light upon the proper conductor, and causing an intermittency or alternation of an electric current. Now, this is almost exactly the method shown by my drawings, and described in my Papers of 1884 and 1885, except that the idea is there shown more developed. Some interesting facts in connection with this will be brought out sooner or later. A large quantity of accessory apparatus, and different methods, have been devised, which necessarily cannot be mentioned here. Finally I would like to put on record the fact that I have four distinct, and what it is thought are practical methods of generating electricity otherwise than by dynamos. The object of writing the above is as a means of protection, both from previous and from future investigators.—Yours, &c.,

Greenport, L.I., N.Y., Jan. 12, 1889. A. B. WORTH.

[Without for a moment wishing to cast the slightest doubt upon the *bonâ fides* of our correspondent, we may remind him that a mere vague declaration of this kind will scarcely enable him to "take date" over any other inventor who may happen to publish his researches before Mr. Worth is ready to do so. We should advise our correspondent to draw up a full and explicit account of his experiments, and to deposit it in a sealed envelope with some recognised scientific authority or institution.—ED. *E.*]

CONSTANT CURRENT REGULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Pressure of business has prevented me from closely studying Mr. Edmunds's courteous reply until now. The first point in it which strikes one is that to prove the work per turn decreases as additional accumulator groups are switched on.

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He says that if whilst generating 70 volts and 70 amperes through an external resistance of 1 ohm another ohm is introduced, the electromotive force immediately rises to 140 volts, the current drops to 35 amperes, and therefore the work per turn being less, the engine speeds up. But are not 70 volts by 70 amperes, and 140 volts by 35 amperes, both 4,900 watts? And if so, why does the simple ringing of the changes on volts and amperes "liberate the engine," the speed and watts remaining the same?

The secret appears to lie in the fact that with constant speed the volts will not rise from 70 to 140 because extra resistance has been put in the external circuit, but that they remain constant at 70, the current alone falling. If this be so, the watts would fall one-half, and the work per turn be halved also, and the engine consequently speed up, but whether it would double its speed appears very doubtful in practice. Seeing, however, is believing, and if Mr. Edmunds would allow me to visit his Cadogan station and see how it is done, I should feel greatly obliged.

Mr. Neville appears to have got exactly the same idea as myself on the subject, but falls foul of me for not appreciating the value of high-speed engines, which I certainly cannot allow to be the construction of my remarks.—Yours, &c.,

DOUGLAS C. BATE.

6, Derwent-grove, East Dulwich, S.E.

[Has not our correspondent overlooked the fact that the torque upon the armature varies with the current only, and is independent of the E.M.F.—ED. *E.*]

ALKALINE ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I did not intend to trespass on your valuable space again on this subject, but the letter of Mr. W. W. Beaumont in your last impression calls for a few remarks from me; I therefore beg the favour of your indulgence.

Your correspondent appears to have misunderstood my communication of the 23rd ult., for I venture to think I clearly stated the grounds upon which I based the claim of similarity in the batteries under notice, viz, that the three principal component parts common to all one-fluid batteries (the electrolyte and the two electrodes) are in each of these identical, these parts being an alkaline electrolyte, *compressed* silver powder, and zinc. But that there are improvements in the manner of dealing with them by Mr. Elwell's friends I freely admit, as I was in duty bound, but certainly not at the expense of explaining away the similarity I endeavoured to point out. There is one point I would like to call Mr. Beaumont's attention to, and that is, that he gives me credit for using silver powder, whereas I said I employed *compressed* silver powder, and that being so, I cannot accept his comparison of the Faure coating and subsequent compressed material as a case in point. I would like to add that although I supported the compressed powder on a silver plate, yet it was fairly coherent. I am satisfied that the result obtained by Mr. Elwell's friends is an advance on this; but the methods differ, I take it, principally in degree.

With regard to the zinc element, no doubt the use of *a* gauze is better than an ordinary zinc plate, inasmuch as it affords increased surface, and a better hold for the deposited zinc. When I read Mr. Elwell's Paper I thought *iron* gauze very unsuitable, for, unless the coating of deposited zinc keeps the electrolyte from contact with the iron, a strong local action must result, at the expense of the zinc. Doubtless, as indicated in Mr. Elwell's letter in yours of the 1st instant, this has been duly considered and provided for. I hope that a wide field may be found for the application of the alkaline accumulator, and wish Mr. Elwell all success in introducing the one he is interested in into this country.—Yours, &c.,

February 5, 1889. H. J. COATES.

HOOKHAM'S ELECTRICITY METER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think the meter you refer to in your "Note" on the above subject is one invented by Dr. Werner Siemens. He patented a meter involving the same general principle as mine a few days after me, in March, 1887. It was not, so far as I can judge from descriptions in the technical journals, a very practical instrument, though founded on a workable principle. In his descriptions of it he made the curious mistake of stating that variations in the strength of the field did not, theoretically, affect the rate of the meter. I can hardly think he ever got to practical tests with it. If he had, practice, if not theory, would have shown him that the rate varies inversely as the field.—Yours, &c., GEORGE HOOKHAM.

Birmingham, February 5, 1889.

GLOBULAR LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: This evening at 7.35 p.m. a fireball about two metres in diameter fell in the direction of Stamford Hill, N. At the same time a fearful explosion took place, lasting some two seconds, and the globe of fire seemed to split into four quarters, showing a bluish fiery light. The explosion was unlike thunder, and was more like a detonation of explosives. A snowstorm of two minutes' duration ensued, leaving 1½ inches of snow on the ground; after which the atmosphere became splendidly clear. It would be interesting to know if this phenomenon has been observed by others in this neighbourhood, and under what conditions. The wind was W.N.W., sky cloudy, and the thermometer stood at 38° F.—Yours, &c.,

Listria Park, Stamford Hill, Feb. 2. ERNST FAHRIG.

THE LIGHTING OF THE CITY OF LONDON.

At a meeting of the Commissioners of Sewers of the City of London, held at the Guildhall of the said city on January 22, a report from the Streets Committee was read, of which the following is an abstract:—

"We beg to report that, having had under consideration the several references and communications made to us from time to time on the subject of electric lighting, we instructed the engineer and solicitor 'to consider and report upon the Electric Lighting Act of 1888, with power to consult with Mr. Preece thereupon, and to prepare conditions upon which proposals for lighting by electricity can be entertained, in order that thereupon the necessary steps be taken with a view to obtain offers on such conditions.'

"Having subsequently received and considered reports from the engineer, Mr. Preece, and the solicitor thereupon, we agreed that the conditions arranged the previous year with a proposed contracting company be taken as the basis of the new specification.

"That it should be obligatory on the companies with whom contracts may be entered into to lay all wires and conductors beneath the public way.

"That the City be divided into three districts, in accordance with the plan prepared by the engineer and Mr. Preece, and alternative tenders be invited for lighting the said districts and the City as a whole.

"That the main thoroughfares be primarily lighted, and be enumerated in the specification; and the companies proposing to contract be required to state the period at which the lighting of such thoroughfares will commence, and when it will be extended to the remaining streets. The Commissioners not to be bound to light the whole of the streets by electricity.

"That it be a condition of any contract that when the profits have reached a cumulative dividend of 10 per cent. the surplus be divided equally between the contracting company and the consumers.

"We referred it to the engineer and solicitor to prepare a specification, based generally on the foregoing resolutions, and having now considered the conditions of proposed contract, as prepared by them, we herewith submit the same for approval by your honourable Court, and recommend that it be referred back to us to advertise for tenders based thereupon.

"Resolved and ordered,—That the said report and proposed conditions be printed and circulated amongst the members of the Court, and the consideration thereof be adjourned until the next meeting."

The report was accompanied by the following:—

Memoranda for Supplying the City of London with Electricity.

[Abstract.]

"The main thoroughfares and public streets, &c., of the entire area of the City are to be lighted by electricity, and for convenience are divided into three districts, and contractors are at liberty to tender for either one or two of the districts or for the entire City.

"The area of the City which is to be lighted is for the purpose of the tenders divided into three districts as follows:—

"No. 1, West District, comprising the area bounded on the north by the City boundary, on the east by Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (north side), Creed-lane, and St. Andrew's-hill, and thence along Queen Victoria-street to Blackfriars Bridge. On the south by the Victoria Embankment, and on the west by the City boundary.

"No. 2, Central District, comprising the area bounded on the north by the City boundary, on the east by Finsbury-pavement, Moorgate-street,

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Princes-street, thence across Mansion House-street, along Walbrook and Dowgate-hill. On the south by the River Thames, and on the west by part of Upper Thames-street, St. Andrew's-hill, Creed-lane, St. Paul's-churchyard (north side), St. Martin's-le-Grand, and Aldersgate-street.

"No. 3, East District, comprising the area bounded on the north and east sides by the City boundary, on the south side by the River Thames, and on the west side by Dowgate-hill, Walbrook, Princes-street, Moorgate-street and Finsbury-pavement.

"The whole of the main thoroughfares in each district are to be lighted.

"The contractor must give a complete description of the lamps proposed to be used, and of the candle-power, both of the arc and the glow lamps. The lamps must be so placed that the light distributed over the surface of the thoroughfares shall be as uniform as possible, and those tendering will have to demonstrate upon a plan and section the relative intensity of this distribution of the electric and gas light. The standard of reference will be the illumination of a square foot of surface by a standard candle at 12·7in. distance.

"The situations of the stations for the generation of electricity, if within the City, are also to be shown, and if not within the City the points at which the main conductors enter the City. The proposed positions of the mains and service pipes or leads, both for public and private lighting, on every thoroughfare must be shown. The system by which it is proposed to supply electricity must be described.

"The contractor must give the price per annum at which each of the lamps will be lighted and maintained, according to the conditions of this specification.

"The whole of the lamps are to be efficiently lighted nightly including Sundays, from sunset to sunrise, and at such other times as the Commissioners, or their engineer, may consider necessary, on account of fogs or other emergencies. Payments will be made in respect of such extra lighting on the certificate of the engineer.

"The existing system of gas lighting must not be interfered with, but the contractor may, in certain cases, be permitted by the consent of the engineer to use any of the existing gas columns or brackets.

"If in the opinion of the Commissioners any street or portion of a district can be better lighted by glow lamps, or by arc lamps of a less intensity than that stipulated in the contract, the contractor is to change and maintain such altered lamps without further charge to the Commissioners.

"All mains and service conductors, both for public lighting and private supply, shall be laid beneath the public ways in such places and in such positions as shall be prescribed by the engineer to the Commissioners, and shall be maintained by and at the cost of the contractor in good order and condition.

"The contractor must take proper and efficient precautions for protecting from disturbance or damage all telegraph and telephone wires, and shall abide by all statutes, regulations, and enactments, and shall hold the Commissioners harmless from any damage that may arise. The contractor will be responsible for complying with all the requirements of the Postmaster-General.

"The contractor must, in all cases where practicable, and permission can be obtained, make use of the subways for laying the mains, but where no subways exist they shall be laid beneath the footways.

"To secure the due fulfilment in all respects of the preceding condition, the contractor upon signing the contract shall deposit the sum of £1,000 in respect of each district with the principal clerk to the Commissioners.

"The contractor is to supply the electricity, conductors, carbons, glasses, lamps, attendance, and everything necessary for the effectual lighting of the district during the contract period. The generating plant is to be the property of the contractor, and at the expiration or determination of the contract for public lighting all connections and fittings supplied or used exclusively for public lighting are to be removed by the contractor, and all paving, and everything else disturbed, is to be reinstated by and at the cost of the contractor.

"So far as the Commissioners are able to do so they will grant to the contractor the exclusive right of supplying electricity for private purposes within the district during the term of the contract. The contractor will be required to supply electricity to any owner or occupier of any premises within a distance of 25 yards of the mains, provided the owner or occupier enters into a fair agreement to defray or divide the cost of the service main, and to pay for the supply of the electricity. The contractor can charge the consumer for the amount of electricity supplied either by meter or by agreement.

"At the expiration or determination of the contract for public lighting the contractor is to have the right to continue to supply electricity for private purposes within the district, and to enjoy free way-leave for all mains and service leads concurrently with other parties, subject to the conditions for regulating the laying of mains and other works, and provided the contract has not been determined by the Commissioners for the following reasons:—

"1. Under the 23rd or 35th conditions.

"2. In consequence of the contractor ceasing to supply electricity for private purposes for a continuous period of one month.

"The Commissioners may at all times whilst the contract is in force test the condition and efficiency of the mains and conductors for insulation and conductivity, in such manner as they deem desirable, and the contractor must afford every facility for this purpose, must provide proper testing places and testing conveniences, and will be required to repair any defect that may be detected within a certain specified period, in default of which a penalty of £20 per day will be exacted so long as the defect continues. The Commissioners will have the power to forbid the use of any main or conductor which they may consider dangerous to public safety, and to order its removal.

"In the event of temporary failure in the electric lighting the Commissioners are to be at liberty to light the streets by gas or any other method, and all expenses consequent upon their so doing shall be paid by the contractor. The contractor will be liable to a penalty of forty shillings per lamp for any and every instance of failure or default in supplying light in any public lamp for any period exceeding five minutes.

"If the profits arising from this contract exceed a cumulative dividend of 10 per cent. per annum upon the capital invested the excess is to be divided equally between the contractor and the consumer. In other words, the contractor will not be entitled to pay a dividend of over 10 per cent. per annum, calculated from the commencement of contract, unless at the same time the cost of the supply of the electricity to the consumer is reduced at the rate of one halfpenny per unit, as per schedule, for each 1 per cent. added to the dividend.

"The duration of the contract for public lighting is for a period of twenty-one years from the completion of the lighting in all the streets, and shall be subject to determination by the Commissioners if the lighting upon the certificate of their engineer is inadequate or inefficient, or if the plant and system have not been maintained in thorough efficiency, any dispute as to the inadequacy or insufficiency of the lighting, and of the maintenance of the system, to be referred to arbitration.

"The Commissioners shall have the option, by giving three months' notice in writing, prior to the expiration of the term of twenty-one years, to renew the contract for public lighting for a further period of seven years, and so on from seven years to seven years by giving a similar notice. Each renewal to be subject to any revision of terms which the success of the contractor, or the improvements introduced in supply or lighting may suggest.

"In the event of the contractor failing, after receipt of due and formal notice at three separate times, with proper intervals, to comply with the conditions of the contract, to maintain the plant, mains, and conductors in proper order, and to provide sufficient electricity, the Commissioners shall have an immediate power to determine the contract as to public lighting, and to order the removal of the mains and conductors, whether used for private or public lighting.

"Power is to be reserved to the Commissioners to acquire the undertaking and works by purchase at the end of twenty-one years, or each succeeding seven years, on giving six months' notice, in accordance with Section 2 of Electric Lighting Act, 1888."

ELECTRIC LIGHTING IN KENSINGTON.

The following is the important part of the report of the Special Committee of the Kensington Vestry appointed to consider matters relating to electric lighting:—

Your Committee, after giving their best attention to the various important and difficult questions raised by the applications of the several electric lighting companies for Licences and Provisional Orders, beg to report as follows for the consideration and approval of the Vestry:—

In the early part of the year 1888 notices were served by the following companies of their intention to apply for Licences to light various portions of the parish of St. Mary Abbotts, Kensington, viz.:—(*a*) Notting Hill Electric Lighting Company (Limited); (*b*) Kensington Court Electric Lighting Company (Limited); (*c*) House-to-House Electric Light Supply Company (Limited),

and in the month of June last notices of intention to apply for Provisional Orders for the same purpose were served by the following companies, viz.:—

1. London Electric Supply Corporation (Limited).
2. Metropolitan Electric Supply Company (Limited).
3. Notting Hill Electric Lighting Company (Limited).
4. Kensington and Knightsbridge Electric Lighting Company (Limited).
5. Chelsea Electricity Supply Company (Limited).
6. House-to-House Electric Supply Company (Limited).

The following two companies gave notice of their intention to apply for Provisional Orders, but have not proceeded further with them:—

Kensington Court Electric Lighting Company (Limited).
West Middlesex Electric Lighting Company (Limited).

1.—Responsibility and Pecuniary Status.

Your committee upon the whole have come to the conclusion that there is no sufficient reason for excluding any one of the companies from Kensington, on account of its want of pecuniary status, or of probable capacity to carry out its undertaking, and therefore

Recommend—

That none of the companies should be excluded on the above ground.

2.—Licences and Provisional Orders Compared.

Another point which has engaged the attention of the committee has been the relative advantages of a system of Licences and of Provisional Orders. Their consideration of this matter has been rendered comparatively easy by the recently-announced intention of the Board of Trade not to grant Licences for any large or important area. Unless, therefore, the Vestry should deem it advisable to make experiments in small areas, instead of assigning the whole or the larger part of the parish to some of the companies now seeking for Provisional Orders, your committee feel that the Vestry have no alternative but to refuse their consent to all the applications for Licences, and to deal with the applications for Provisional Orders only. Your Committee fear that some at least of the companies would not be induced to incur the necessary expenditure upon the security of a Licence, and are unwilling to refuse to those companies who have incurred, or are incurring, considerable expenditure, that larger concession which

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they would have to grant to other companies if they are to be induced to take up the work ; they therefore

Recommend—

That, with the exceptions hereinafter mentioned, the Vestry refuse consent to all Licenses applied for by the above.

3.—Competition v. Monopoly.

Your Committee have been more particularly occupied in the consideration of the question how they can combine the benefits of competition with those of a well-regulated monopoly. To those who remember the inconvenience which arose to the public from the frequent interference with the streets by rival gas companies, the advantage of having the electric light supplied by only one company will be apparent ; whilst to those who have suffered from the high charges and insufficient service of a company with a monopoly, the advantage of competition is self-evident.

Your Committee would observe that it is enacted by the Electric Lighting Act, 1888, sec. 1, that "the grant of authority to any undertakers to supply electricity within any area, whether granted by Licence or by means of a Provisional Order, shall not in any way hinder or restrict the granting of a Licence or Provisional Order to the local authority, or to any other company or person within the same area." It is clear, then, that no legal monopoly is given to any company by the granting to it alone in the first instance the right, by Provisional Order, of lighting any part of the parish.

Your Committee are of opinion, upon the whole, that considering the right the Vestry will have, if circumstances should require it, to obtain themselves, or to consent to other companies obtaining, Provisional Orders to light the same districts as other companies, it is better in the first instance to assign a given portion of the parish to only one company. They thus gain a comparative amount of freedom from disturbance to the streets, and avoid the unnecessary reduplication of mains in streets and consequent waste of capital. As each company will know that its immunity from direct competition in its own district depends upon its good conduct and the reasonable nature of its service and charges, it will have, in the opinion of your committee, sufficient inducement to carry on its undertaking efficiently and economically, and thereby the parish will get the advantage of a potential competition. It may, however, be a question whether the Board of Trade should not in each Provisional Order place a larger district than that primarily conceded to each company in a separate schedule, with a provision that the company should not supply electricity in such extended district until after the Vestry has at two successive meetings (after certain specified notice to the company in whose original district such area was included) passed resolutions that it is desirable there should be a second company authorised to supply electricity in such extended district. Your committee propose, with your approval, to request the Board of Trade to consider the expediency of such a provision, as rendering the potential competition a more powerful inducement to efficiency and low charges ; they therefore

Recommend—

(*a*) That in the first instance only one company have any portion of the parish conceded to it by Provisional Order for lighting purposes ; (*b*) that the Board of Trade be requested to arrange for an extended area of supply being included in each Provisional Order, subject to such conditions as are above suggested ; (*c*) that such last-mentioned area should in each case include all that portion of the parish applied for by each company, but which is not comprised in the area to be assigned to the company in the first instance.

4.—Districting of Companies.

Assuming, therefore, that the Vestry agree with your Committee that, upon the whole, it is better to assign in the first instance a separate district to an individual Company, your Committee

Recommend—

That the following companies (some particulars of each of which are given) should have the district allotted to it which is described.

(1) London Electric Supply Corporation (Limited).

This Company includes in its Provisional Order more than half the Metropolis, and your Committee do not therefore consider themselves justified in assigning to it any part of the parish which is likely to make an immediate demand for electricity.

At an interview with one of the directors of the company, your Committee understood that the company would not be likely to accept the above, which was the only proposal the Committee felt justified in making, and therefore further

Recommend—

That, in the event of its not being finally accepted by them, District No. 1 be added to that offered to one of the other companies.

(2) Metropolitan Electric Supply Company (Limited).

This company is also a large and important one. It proposes to supply the electric light in a considerable part of London, and your committee therefore are unable to say how much of the £500,000 already subscribed is already forestalled for other districts.

(3) Notting Hill Electric Lighting Company (Limited).

This company has not yet called up any capital or constructed any works, but your Committee are satisfied that it is a *bonâ fide* concern, well supported both by engineering talent and by gentlemen of local influence, and believe that if a Provisional Order is granted the company will at once apply itself to carrying out works in the district assigned to it.

(4) The Kensington and Knightsbridge Electric Lighting Company (Limited).

This company already holds a Board of Trade License for the Kensington Court district and adjoining parts, and has raised and expended a considerable amount of money (shown in the appendix) in constructing central stations, the one at Kensington Court having been for some time in operation, and the other in Chapel-place, Brompton-road, being in course of construction. From these two centres the company can conveniently and economically light the area which it is proposed to include in their Provisional Order, and which contains within it the smaller district, now successfully lighted by the company under their existing License, and another district which your Vestry have consented to their obtaining a License to supply, pending the grant of the Provisional Order and its confirmation by Parliament, which, when granted, will supersede the two Licenses.

(5) Chelsea Electricity Supply Company (Limited).

This company obtained a Provisional Order in 1886 for the supply of electricity in a considerable area of Chelsea. Some delay has arisen in the construction of their works, which, however, are now being carried out. The contract for the construction of the works binds the contractors, your Committee are told, to an early completion under heavy penalties, and the company state that they will shortly be in a position to supply the electric light.

(6) House-to-House Electric Light Supply Company (Limited).

This company is now in a position to supply a large number of lights, whilst its works are so constructed as to be capable of extension with a view to generate a much larger amount of electricity when the demand requires it.

With regard to the three last-mentioned districts (4, 5, and 6), which together make up the whole of the parish south of the Kensington-road, it will be observed that the line of railway from High-street, Kensington Station, to South Kensington Station has been adopted as the dividing line, as it is believed that the railway tunnel affords facilities for conducting electric mains along it which are likely to be made use of by some, if not all, the companies, to the relief of the public streets.

5.—Provisions for Safety.

Whilst your committee have not overlooked this most important matter, they do not consider it necessary to make a special report to the Vestry upon the provisions which should be adopted to prevent accidents, as they believe such provisions will be more effectually secured by the action of the Board of Trade. They therefore

Recommend—

That the Board of Trade be requested to make such provisions under this head as they may think fit.

6.—Overhead Wires.

As regards overhead wires, your Committee

Recommend—

That no company acquiring any powers in Kensington shall be at liberty to carry any wires otherwise than under ground, and that all wires previously placed overhead by any such company shall, on any License or Provisional Order taking effect, be removed and placed underground.

All the companies practically agree to this requirement.

7.—Mode of Laying Wires.

Your committee are anxious that some uniform system of laying down wires should be adopted by all the companies serving any part of the parish of Kensington. They are not prepared without further consideration to advise the Vestry what such system should be, but

Recommend—

That the proper objections should be made to the Provisional Orders, with the view to securing (*a*) the adoption of the best mode of laying down electric mains, wires, and lines ; (*b*) that all work shall be done to the satisfaction of the Vestry ; (*c*) That the Vestry, should they so determine, shall have power to lay down culverts or channels at their own expense, and to require the companies to use the same, paying a reasonable rent for the accommodation.

8.—Generating and other Stations in Parish.

As several of the companies will have works for generating and storing electricity in the parish, your Committee consider that the Vestry should have a right of veto upon their being placed in positions or otherwise so constructed or used as to be detrimental to the neighbourhood. In particular they would urge that no engines of a non-condensing character be constructed, and that the best Welsh or other smokeless coal shall always be used in the furnaces, and generally that the works in the parish be constructed and managed to the satisfaction of the Vestry ; they, therefore,

Recommend—

That the Board of Trade be asked to insert clauses to this effect in the Provisional Orders.

9.—System of Charging ; and 10.—Maximum Price.

The system of charging for electricity is very various in the different Orders, and will require revision.

The Board of Trade unit of 1,000 amperes* has been changed in some of them to one of 10,000 amperes, without, apparently, sufficient reason, unless it have the advantage of facilitating the working of a sliding scale hereinafter referred to. Your committee therefore

Recommend—

That this matter, with various other details connected therewith, be left to your Committee, who would raise all necessary objections, so as to enable them afterwards to settle the clauses by conference with the companies, or, if necessary, by referring any difference to the Board of Trade.

[*We were under the impression that the Board of Trade unit is expressed in terms of watt-hours.—Ed. *E.*]

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11.—Revision of Charges and Sliding Scale.

One company (the House-to-House Company) proposes a provision for the revision of charges at the end of seven years, and the establishment of a sliding scale of price and dividend analagous to that adopted of late years by Parliament in the case of Gas Companies. The following is a copy of the provision:—"At the expiry of the first seven years of this Order the undertakers agree to the fixing by arbitration in the usual way of a standard price to be charged by the undertakers for electricity on the basis of 10 per cent. per annum of clear profits, provided that the undertakers may increase or diminish such standard price, subject to an increase or decrease in the standard rate of dividend (10 per cent.), to be calculated as follows:—For every penny or part of a penny charged in excess or diminution of such standard price in any year, the standard rate of dividend shall for such year be reduced or increased by five shillings in the hun ired pounds per annum.'

A somewhat similar provision is contained in the Notting Hill Company's provisional Order.

Without committing themselves to the words of either of these proposed provisions, your committee believe that no greater inducement to economy in working could be found, and that thereby the consumer will have as good an opportunity of an early reduction in price as would be found either in any other statutory provision, or in the direct competition of two companies in the same area, and

Recommend—

That some such provision should be accepted as regards the above company, and as regards other companies, inserted in their Provisional Orders.

12.—Appropriation of Separate Capital.

In order to secure the proper working of the sliding scale, it is necessary that the amount of capital properly spent in accommodating the district should be correctly ascertained, and in doing this, with the existing knowledge on the subject, there must be considerable difficulty. Some of the Provisional Orders are altogether silent upon the subject of capital: your committee therefore

Recommend—

That the Board of Trade should be urged to insert clauses in all the orders as to the capital to be specially appropriated in supplying Kensington with electricity, leaving to the committee the details of the objec tions which should be raised under this head.

13.—Purchase of Undertaking.

Section 2 of the Electric Lighting Act of 1888 provides that the local authority shall have an option of purchasing the undertaking after the expiration of forty-two years, or such shorter period as is specified in the Act confirming the Provisional Order, from the date of passing such Act, and also after the expiration of every subsequent period of ten years, or lesser period specified in the Provisional Order. Your Committee think that a shorter period than forty-two years should be inserted in the several Provisional Orders, and have reason to believe that all the companies would consent to the first period being twenty-one years, and the subsequent periods seven years, and they

Recommend—

That your committee should be authorised to endeavour to obtain this concession as a condition of the Vestry giving its approval to the Provisional Order.

Temporary Licences.

In the event of the system of districting recommended by your Committee being approved by the Vestry, it would seem desirable, with a view to bringing the electric light into early use, that the Vestry should consent to a License being granted by the Board of Trade to such of the abovementioned companies as may be ready to supply electricity within the next few months in the areas which it is contemplated they should light under the Provisional Orders. If any such company would adopt the terms of the License granted to the Kensington Court Company in October, 1887 *(mutatis mutandis)* as the terms of such a temporary License, your committee

Recommend—

That the Vestry should give its consent for grant of such License by the Board of Trade, upon the condition that such License should be superseded by the Provisional Order when confirmed by Parliament, and if not so confirmed, should not last for more than a year or eighteen months from the date of such License.

(Signed) Jno. Jordan, Chairman.

The report was unanimously adopted in a full Vestry.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

Note.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

January 7, 1889.

266. Thomas Boothby. London. A bracket to support the ear-piece of telephones and other instruments.

276. C. Grant. Glasgow. Portable dynamo-electric signalling apparatus for military and other purposes.

278. G. Wehr. London. Lightning conductor for telegraphic purposes.

282. F. Coates. London. Improvements in conduits for electric mains.

292. P. F. Luck. London. Improvements in electric alarm thermometers.

January 8, 1889.

320. W. P. Kookogey. London. Improved methods of preparing solution compounds for galvanic batteries.

342. W. M. Mordey. London. Improvements in or relating to the regulation of dynamo-electric machines.

361. H. H. Lake. London. Improved methods of and apparatus for welding, forging and otherwise working metals by the aid of electricity (E. Thomson, United States).

362. H. H. Lake. London. Improved methods of and apparatus for welding, shaping and otherwise working metals by the aid of electricity (E. Thomson, United States).

377. H. H. Lake. London. Improvements relating to the riveting of metal plates and other objects by the aid of electricity (E. Thomson, United States).

January 9, 1889.

385. J. A. Wilson and F. M. Young. Dundee. Improvements in electrical apparatus for preventing collisions between railway trains.

435. J. H. Holmes. Newcastle-on-Tyne. Improvements in dynamo-electric machines.

January 10, 1889.

485. H. E. Newton. London. Improvements in electric generators (D. Piédrahita, France).

January 11, 1889.

506. H. H. Lake. London. Improvements in electrical switches, chiefly designed for use in connection with apparatus for obtaining synchronic movements for telegraphic and other purposes (E. F. Law, Turkey).

549. H. W. C. Cox. London, E.C. Indicating the level of water, or contents of liquids in tanks or other vessels, by means of a transmitter and recorder worked by means of electricity.

January 12, 1889.

586. F. Bathurst. London. Insulating blocks for use with casings containing electric wires.

588. B. M. Drake and J. M. Gorham. London. Improvements in secondary batteries.

608. W. Armstrong and A. F. Ball. Newcastle-on-Tyne. Firing fog or other signals upon or in connection with a railway or tramway, either electrically or mechanically, the same being under control of authorised person.

614. W. N. Naylor and W. J. Naylor. London. An improved form of electrical locking switch.

SPECIFICATIONS PUBLISHED.

1887.

17,209. Willing and Douglas. Combined switch electric lamp support for conveyance. (Price 8d.)

1888.

1,091. Aird. Electrically released counting mechanism. (Price 8d.)

1,254. Spink and Gauzentes. Electric lamps. (Price 8d.)

1,798. Laurie. Telephonic transmitters. (Price 8d.)

1,843. Mewburn (La Société Anonyme pour la Transmission de la Force par l'Électricité). Rheostats and rheotomes. (Price 8d.)

1,919. Howes. Arc electric lamps. (Price 8d.)

2,073. Iwanowski. Electric alarm apparatus. (Price 8d.)

2,251. Graham. Electric circuit switches. (Price 8d.)

2,368. Bailey and Warner. Secondary batteries. (Price 8d.)

2,438. Langhans. Incandescent electric lamps. (Price 6d.)

2,450. Hibbert. Electrical measuring instruments. (Price 8d.)

8,950. Burdon. Electrical traction. (Price 6d.)

10,604. Timmis. Secondary batteries. (Price 6d.)

11,082. Newton (Gray). Transmitting and recording electrically autographic messages, &c. (Price 1s. 3d.)

13,232. Bellhouse and Cookson. Curative belts. (Price 6d.)

16,099. Dorman and Smith. Electrical switches. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The Cuba Submarine Telegraph Company (Limited).

The thirty-fifth ordinary general meeting of the shareholders in this Company was held at the offices of the Company, 58, Old Broad-street, E.C., on Wednesday last. Mr. Joaquin de Mancha presided.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, it is always a pleasant duty to meet our fellow-shareholders on these occasions, particularly when we can present so good an account, which I think you will all be satisfied with. You will remember that we carried from the last year's account £1,195. To that we have been able to add out of the six months' working, which is the worst six months of the year, the sum of £20,708, which I think is very

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satisfactory, our messages having increased during that time by 3,440. Out of that we now propose, with your permission, to declare a dividend on the Preference shares at the rate of 10 per cent., and on the Ordinary shares at the rate of 9 per cent. per annum. I think that, having regard to the difficult nature of the business in which we are engaged, that is a gratifying result. I can only hope that we shall continue to be able to pay the same dividend in the future. You are aware that the French cable which we have been threatened with so long has at length been laid from Venezuela to San Domingo, Hayti, and from there to Cuba. We did all that we could to see that our rights were not trenched upon. Mr. Scott went to Madrid to our agents there, and gave them all the requisite information and instruction to protect your interests. Mr. Keith, our manager in Cuba, also did all he could by putting our case properly before the Government officials to see that we were not at all prejudiced. I hope that nothing will occur to injure us, and that we shall go on working as prosperously as we have hitherto done. The only other matter to which I would call your attention is what we say about the Cienfuegos-Batabano section of our cable. Cables, like ourselves, do not last for ever. It has been laid a long time, and there are occasionally small interruptions in it. Mr. Keith having been over here, we engaged a steamer which is going to take out cable sufficient for any repairs that may be required, so that the traffic may not be delayed, and we hope that with the appliances we have sent him he will be able to keep things in perfect order. If by any chance there should be a greater injury to the cable than we have as yet experienced or anticipated perhaps we may have to duplicate it. That is why we are always so careful to keep the reserve fund as strong as possible. It is a security both to the preference and the ordinary shareholders, and if we had to come upon our earnings for anything of that kind we should have to reduce the dividend. I hope, therefore, you will approve of our policy in always keeping a good fund in hand to meet any repairs that may be required, and I think when you look at the amount which our reserve fund has grown to—£84,000—I think you need not fear that there is not enough not only to repair any portion of our cable, but to leave sufficient in hand for any future emergencies. He concluded by moving the adoption of the report and accounts.

Mr. ALEXANDER F. LOW seconded the resolution.

Mr. KEENLYSIDE suggested that as the Company earned 15 per cent., out of which 6 per cent. went to the reserve fund, they should be content with putting aside only 5 per cent., and thus allow 1 per cent. more to be divided among the shareholders.

Mr. COCHRAN hoped that the body of the shareholders would endorse with unqualified expressions his approval of the policy of the Board in building up a good reserve fund. It was the great security of the Company against future contingencies.

The CHAIRMAN said that his own feeling in the matter was that he would like to see the fund up to £100,000. Then they might feel quite at ease, for whatever occurred they would be in a position to lay the cables afresh.

The resolution was carried unanimously.

Subsequently a resolution was carried declaring the dividends recommended, namely, at the rate of 10 per cent. per annum on the Preference, and 9 per cent. per annum on the Ordinary shares of the Company.

The CHAIRMAN said he would be sorry if the shareholders parted without giving an expression of their approval of the zealous manner in which the staff of the Company had performed their duties. He always found that their *employés*, both here and abroad, displayed great intelligence and diligence in their work, and he was sure it would be a great source of satisfaction to them to hear that the shareholders appreciated that fact.

Mr. COCHRANE seconded the motion, which was unanimously carried.

The SECRETARY briefly returned thanks.

On the motion of Mr. SQUIRE, seconded by Mr. GREENWOOD, a cordial vote of thanks was accorded to the Chairman and Directors, who, Mr. Greenwood remarked, were the right men in the right place.

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

The German Union Telegraph and Trust Company (Limited).

The eighteenth and final ordinary general meeting of the shareholders of this Company was held at Winchester House, Old Broad-street, on Wednesday last, Sir James Anderson presiding.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting and the minutes of the last ordinary and extraordinary general meetings, which were confirmed by the present meeting and signed by the Chairman as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN, in moving their adoption, said that he confessed to some disappointment in meeting the shareholders on that occasion, inasmuch as when he last addressed them he had held out hopes of their getting very nearly par for their shares, the calculation they had made being within 1s. or 1s. 6d. of their full value; but since that time there had been a cable broken which it had cost the Company no less than £7,684 to repair. That would amount to a charge of 6s. 8d. on each original share. The money sent over here was sent in marks, and the exchange was something like 5¼d. against the Company, so that the money that would be posted to them that day would be £7. 6s., the total sum they would ultimately receive for their shares being about £9. 10s.

Mr. HERMANN GUSTAV ERICHSEN seconded the motion, which was carried unanimously.

An extraordinary meeting was subsequently held, at which the special resolutions passed on the 22nd January, requiring the Company to be wound up voluntarily, and appointing Sir James Anderson and Mr. Wm. Payton liquidators, were confirmed.

Mr. LOWENTHAL proposed a vote of thanks to the Chairman and Directors, which was seconded by Mr. GRIFFITH, and cordially agreed to.

The CHAIRMAN returned thanks, expressing his regret that the Company was broken up after so prosperous and promising a career.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of this Company was held at Winchester House, 50, Old Broad-street, on Friday, the 1st inst., the Right Hon. Viscount Monck presiding.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the minutes of the last meeting, the latter being confirmed and signed by the Chairman as correctly entered.

The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, the report being taken as read, I desire, in the first place, to express my acknowledgments to the stockholders generally for excusing my attendance at the last half-yearly meeting, and to my noble friend on my left (the Marquis of Tweeddale) for the kindness he showed in undertaking my duties on that occasion. At the moment I was affected by an attack of illness which was neither serious nor dangerous in itself, and it has passed away without leaving any serious trace behind it, but it had effects at the time which thoroughly disqualified me from taking my place as Chairman of the general meeting. I think, however, you will agree with me, that so far as your interests were concerned very little apology for my absence is necessary. The manner in which my noble friend discharged the duties, which he so kindly undertook at so short notice, left nothing to be desired on your part, and, to say the least of it, prevented any mischief that might have occurred owing to my absence. Gentlemen, on these occasions the topics for discussion are not very extensive. They lie within a narrow range, and when you discuss the condition of your plant, the expense of maintaining and repairing it, the revenue which you have derived from its working, and the prospects of the Company, you have nearly exhausted the category of subjects upon which it is necessary to comment. In proposing that the report and accounts be adopted, I would say a few words on each of these matters. With regard to your plant, you will observe from the report that, with comparatively trifling exceptions on the other side of the Atlantic, it is in very good condition. We have had, as you have heard, a good deal of repairs during the past half year. There are one or two observations which I should like to make connected with them, and which I think are not on the whole unsatisfactory. In the first place those repairs have been done entirely by your own steamer. This gives you the advantage of having your repairs done at first cost, and it further demonstrates the necessity or advisability which exists for keeping your own repairing ship. Your deep sea cables have been all in good order except the cable of 1869—the original French cable—upon which we have had very considerable repairs to effect. We picked it up in two or three places at a depth of nearly 2,000 fathoms, and successfully repaired it. It is now in its twentieth year. I confess it makes me feel rather old to find my bantling so nearly approaching its majority; but I am glad to say it is doing very good business, and we have been able to put it in thorough working order this year. So much with regard to the repairs and condition of your plant. With respect to the expenses, which have been incurred independently, of course, of repairs and renewal of cable, there is not much to be said. During the half year we have attended most carefully to the expenditure, and endeavoured to reduce it as much as possible; but if you will take the trouble of comparing two or three of the annual reports, and looking at the details of the expenses which are given at the end of them, I think you will find that there is a very small portion of the expenditure over which the Directors can exercise any great control. You must pay your wages, you must feed your people, and you must maintain your lines, upon which the greatest expense generally occurs. I do not think, however, that you will find on comparison that there is very much difference between the last few half years in the items of expenditure. As a matter of fact, the outlay for the present half year is, it appears on the face of it, £1,000 less than it was in the corresponding half of last year; and when you come to look into it you will find that there is some extraordinary expense in that half year which really takes the matter out of the category of comparison. There is an item in the expenditure to which I would draw your attention, because it puts us in a position of safety for the future, and that is the estimate of the amount which the French law suit will cost us. We have debited ourselves with £2.000 for the costs of that, and we believe that is an ample estimate of the amount they ought to come to, and therefore the item will not appear again in your accounts. With regard to our income and prospects, we meet to-day under conditions, I am happy to say, which, if they do not give rise to any effusive jubilation, are at all events more satisfactory than they were at our recent meetings. It will be in your recollection that in July, 1887, your Directors announced that their policy was to adopt a very small tariff, not as a hostile measure, although to a certain extent there must be some hostility wherever there is competition, but to test by experiment what tariff was the lowest that we could give the public consistently with leaving to ourselves a moderate return. We announced at the time that we intended to adopt the 6d. rate, and to maintain it for a long enough period to give us experience of its effects. I may say—and I have no doubt that most of the shareholders are aware of the fact—that the receipts at different seasons of the year vary considerably, and therefore an experiment made in the autumn would not be a sure guide with reference to the whole year. Well, we maintained the 6d. tariff for more than one year, and I think we proved to the thorough dissatisfaction of every one concerned that in the present condition of Atlantic tele-

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graphy a 6d. tariff would not pay any one. The result of that was, as you are aware, that we increased the rate to 1s. a word. The experience that we have had of that rate, for the reasons that I have mentioned, has not been long enough to enable us to decide whether it is a satisfactory one or not; but up to this time it has not been unsatisfactory. I trust that the same reasonable conduct which induced the different companies engaged in telegraphy in the Atlantic to raise the tariff to 1s. will also induce them to go further if it becomes absolutely necessary, in order to get to the limit at which it will pay; but, as I have said, the period during which the 1s. tariff has been in operation has been too short to enable us to arrive at a definitive decision as to the propriety of maintaining it at that figure. But I hope that we may be able, by the exercise of moderation and forbearance towards our adversaries, to fix ultimately on a tariff which, without bringing you in such large returns as to induce further competition, will give you a moderate and remunerative return for the money you have invested in the concern. With these observations I beg leave to move—

"*That the report of the Directors, and the accompanying statement of accounts to the 31st Dec., 1888, submitted to this meeting, be and the same are hereby received and adopted.*"

The MARQUIS OF TWEEDDALE seconded the motion.

Mr. SMITH (York) congratulated the Directors on the improved condition of the Company and its prospects, and said it would be a source of satisfaction to the shareholders if the Chairman would state how they stood in reference to the litigation still pending between the Company and the Paris and New York Telegraph Company. He had been connected with the Company a great many years, and the present was the best report he had seen for four or five years.

Mr. GUESDON thought it must be very encouraging to all interested in cable enterprise to think that the Company's oldest cable was in such good condition. When they took into account the very great improvement that had been recently effected in the manufacture of cables, he thought that the life of a cable now might be calculated on with a great deal more confidence than it could have been a few years ago. It was a very agreeable fact to find that the destructive competition among the rival companies had terminated. He looked upon the 1s. tariff with great favour, and he hoped that when the agreement between them terminated 12 months hence some understanding would be arrived at whereby the 1s. tariff would be maintained and unity established among the companies. The Directors had had the firmness to refuse to pay a dividend during the time that they had carried on the "war," and had built up a reserve fund which greatly strengthened the position of the Company. Another fact which he thought the Directors would have realised by this time was that it was necessary, in order to shut out unhealthy competition, to be satisfied with moderate profits. His hope was that by the expiration of the 12 months, the various Atlantic telegraph companies would come to some permanent arrangement by which competition would be done away with.

Mr. CHIPPERFIELD asked whether there was now a joint purse with all or with how many of the cable companies; whether it was not the Anglo-American Company that gratuitously initiated the charge of 6d.; how soon the other companies followed suit, and who suggested a return from 6d. to the 1s. tariff? He thought the subjects mentioned by the Chairman as coming properly under discussion among the shareholders were very unimportant compared with the question of tariff charged. When they adopted the 6d. charge he felt that it was a most suicidal course, and he thought that the result proved it to have been so. He could not conceive how gentlemen with the experience of the Board could have done such a foolish thing, and their conduct in that matter, if they gratuitously took the initiative, as he assumed they did, deserved severe condemnation.

Mr. WOOD expressed his regret that the 6d. rate, which he thought would be the rate of the future, could not be maintained. It ought to be their aim to keep down the tariff as low as they possibly could, so as not to make enemies of the telegraphing public, which they had done for a long course of years. He desired to ask the Directors what they thought would be the "life" of a cable, and from what they had seen whether it was likely that the old cable, which had just been repaired, would serve other five or eight years?

Mr. JACKSON said that paragraph 7 of the report was to him the most emphatic and conclusive evidence that the policy of the Board was the right one. The statement that peace had been established among all the companies doing telegraph business across the Atlantic was most important to the shareholders, and he wished to accentuate the hope of Mr. Guesdon that at the end of twelve months every courtesy would be extended to their rivals, with the object of bringing about permanent unity among the companies. As to the remark of the gentleman who attacked the Board for taking the initiative in adopting the 6d. tariff, he must remind the meeting that the Directors appealed to the shareholders and got their universal assent to that policy. He unhesitatingly said that for the last five years they had not been in so sound, satisfactory, and promising a condition.

After some remarks from Mr. PICTON and Mr. HUMPHRIES,

The CHAIRMAN, in reply, said: I do not think there has been any question raised to require a very long answer from me. Mr. Chipperfield denounced the conduct of the Directors in very unmeasured language, and said we could not have had brains to do such a thing as to adopt the 6d. tariff. Mr. Chipperfield looks old enough to recollect the reduction of the postage rate to 1d., and he must remember that when the postage was higher the Post Office did not pay. When it was reduced to 1d. after a few years the Post Office became a source of revenue to the State, and is now a very large contributor to the annual revenue of the country. When we are told that the application of the same principle to your business was an act of folly we may fairly quote that instance against Mr. Chipperfield's argument. At all events, I do not think that the observations of the honourable gentleman carried the meeting with him. I was asked a question with reference to the probable life of the 1869 cable. All I can say is that I hope it will last for a very considerable time; and I may tell you that wherever the cable has been picked up with favourable conditions at the bottom of the sea it was as good as it was on the day when it was laid. But there are certain points at which the conditions of the bottom of the sea are very unfavourable to a cable, and they caused a good deal of friction, which destroyed the cable in certain places. But the great body of the cable is, I believe, as good as it was the day it was laid. The experience we have had during the last few years has shown that applied science has been brought to such perfection that you can really pick up a cable at a depth of three miles as easily as you could pick it up from this floor and effect repairs. So far as we can judge, this cable may last for a great many years yet. As far as I could understand Mr. Humphries, he wished us to issue Four per Cent. Debentures and buy up our own stock. I need not tell you that that would be a grossly illegal act. The only other remark to which I think it necessary to allude is that made by Mr. Smith with reference to the law suit we are carrying on in France, and if you will allow me I will ask our law agent to explain how that stands.

The SOLICITOR (Mr. Burt) said that the meeting would remember that their action against the Paris and New York Company was commenced in the Tribunal of Commerce of Paris. In that court the Company obtained a satisfactory judgment. The defendants appealed from it to the Court of Appeal in Paris, which, while expressing itself, as it appeared to him, in favour of the Company's claim doubted whether the Tribunal of Commerce had jurisdiction to give the judgment which was given. In the concession held by the French Company it was stipulated that any question arising between the Government and the holders of the concession should be decided not by the ordinary law courts but administratively by the Conseil de Prefecture de la Seine with the right of appeal from that Council to the Council of State. The Court of Appeal said: "Before we decide this question you must go to the Conseil de Prefecture de la Seine in order that they may, in accordance with the terms of the concesssion, determine what was the legal value of the letter written by the French

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Minister of Posts and Telegraphs to the Paris and New York Telegraph Company, on which they broke the contract." That reference to the Conseil de Prefecture de la Seine was now pending, and was arranged to be heard on the 26th of this month. He could not hold out the hope that that would be an end of the question. Whichever side lost would probably appeal to the Council of State. On the administrative question they would have to go back to the Court of Appeal, and then they would decide between them. He was sorry that that should be the case. £2,000 was the estimate of the proportion of this Company's expenses in the French Courts, and he might say that the expenses in France were quite equal, if not superior, to those in the English tribunals. In further reply to Mr. Smith, of York, he added that it was not possible to obtain a deposit for the amount of the damages which were alleged. They would have had to give security for the return of the money, together with compensation for all the loss which the other side had sustained, and they were advised by the ablest lawyers in Paris that it was much wiser on that account not to ask for the deposit.

The resolution was then put to the meeting, and carried unanimously.

Sir James Anderson and Mr. Wm. S. Cunard, the retiring Directors, were re-elected, as were also the auditors, Mr. Joshua Dean and Mr. Francis Glass.

Mr. CHIPPERFIELD proposed, and Mr. GUESDON seconded, a vote of thanks to the Chairman, which was cordially passed, and

The CHAIRMAN having briefly acknowledged the compliment, the proceedings terminated.

Taunton Electric Lighting Company.

The second annual meeting of the shareholders in this Company was held at the Castle Hotel, Taunton, on Monday evening, under the presidency of Mr. W. H. Fowler, the Chairman of the Company.

The CHAIRMAN moved the adoption of the report of the directors (which appeared in our last issue). He said it was a very satisfactory thing that at this end of their second year they were able to pay an increased dividend, and at the same time to make proper provision for depreciation of plant, and for any extraordinary expenditure that might come upon them. They had carried forward a sum of £207. 13s. 7d., and as the machinery was kept in its highest efficiency he thought they could consider they were fully justified in paying an increased dividend. At the same time it was absolutely necessary to enlarge their plant, and they would be unable to do so unless they had further help from the general public. If others were prepared to back him up, he would put a further sum of £500 in the Company, because he was fully satisfied that the thing would be a success provided they made it large enough to meet the demands of the general public.

Mr. O. E. LANCE seconded the adoption of the report.

Mr. H. G. MASSINGHAM, the managing director, said the revenue had increased by 45 per cent. during the past year, and he thought there was every probability that next year they would earn a dividend of not less than 7 per cent., for at present they had a large number of customers waiting whom they were unable to supply until they had additional plant. Whereas two years ago they commenced with one dynamo, they now possessed six. He believed it was the most successful installation in England, and they had been very fortunate in not having any accidents.

Mr. POTTER, a director, stated that the success of this Company was unprecedented in the history of electric lighting in England.

The retiring directors and auditor were re-elected and thanked for their services, and a vote of thanks to the chairman terminated the proceedings.

The India Rubber, Gutta Percha and Telegraph Works Company (Limited).

Report of the Directors for the year ended December 31, 1888, to be presented to the twenty-fifth ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, London, on Thursday, the 14th inst., at half-past one o'clock :—

The accounts show the net profit for the past year to be £57,157. 14s. 2d. Adding £9,530. 3s. 5d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £45,887. 17s. 7d. The Directors recommend the distribution of a dividend of 10s. per share, free of income tax, amounting to £20,800, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £25,087. 17s. 7d. to be carried forward. The Company's general business continues to increase ; but competition is as keen as ever, and only a low rate of profit can be made. The submarine cable work of the year has consisted of several items of small amount. The works are now occupied in the manufacture of about 800 miles for the Eastern and South African Telegraph Company, to be laid in May on the West Coast of Africa, in extension of the West African Telegraph Company's cables manufactured and laid by this Company. The Company's works and machinery are in efficient working order. Mr. Scott and Mr. Henderson, the Directors retiring by rotation, offer themselves for re-election. The auditor, Mr. Weise, retires, and is re-eligible.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 1st amounted to £4,796.

CROMPTON AND CO.—The directors have declared an interim dividend of 7 per cent. per annum upon the Preference shares of the company for the five months ended 31st December last ; they have also decided to pay at the same time the 4 per cent. interest to same date upon the amounts paid in full in advance of calls.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of January was 3,922, estimated to produce £3,100, against 4,064 messages, producing £3,366 in the corresponding month of last year. The traffic receipts for the month of October, estimated at £3,300, realised £3,316.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January were £1,880, as compared with £1,943 last year.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January were £65,835, as compared with £56,164 for the same period last year, or an increase of £9,671.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January were £41,820, as against £39,878 for the same period last year.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company are as follows :—January, 1889, £22,400 ; corresponding month, 1888, £21,400 ; corresponding month, 1887, £20,400.

LONDON AND PROVINCIAL ELECTRIC LIGHTING AND POWER GENERATING COMPANY.—Mr. Justice Chitty has appointed Mr. Lionel H. Lemon, chartered accountant, official liquidator of this company, in place of Mr. W. Lott Grimwade.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—The directors propose a dividend of 15 per cent. (£1. 16s. per share) in addition to the 5 per cent. already paid, making 20 per cent for 1888, being the same as for 1887.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 1st, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,691.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended 31st January, 1889, amounted to £6,125.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended January 31st, 1889, were £2,770, as compared with £3,279 in the corresponding period of 1888. The October receipts, estimated at £5,197, realised £5,325.

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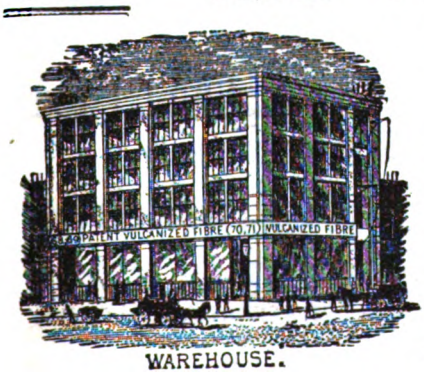

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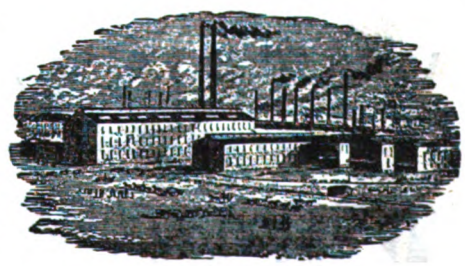
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Feb. 6, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Feb. 6, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	7/6	Anglo-American	50 51	2 13 5	Jan., Apr., July, Oct.	50½	50
2,614,820	Stock	15/0	Do. Preferred	84½ 85½	3 16 0	" "	85½	84½
2,614,820	Stock	5/0	Do. Deferred	17 17½	...	February	17⅝	17
130,000	£10	3/0	Brazilian Submarine	13⅜ 14	5 0 0	Mar., June, Oct., Dec	14	13½
112,900	£100	5%	Do. 5 per Cent. Bonds xd	101 103	4 17 1	January and July	101	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 14⅝	5 15 3	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19⅛	5 2 7	" "	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3 4	3 10 0	March & September	3⅜	3 1/16
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9⅜ 10⅛	3 19 0	Jan., Apr., July, Oct.	10⅛	10
380,000	10	2/6	Eastern	12⅜ 13	4 12 4	" "	12⅛	12⅛
70,000	10	3/0	Do. 6 per Cent. Preference	14⅜ 15¼	3 16 8	" "	15¼	14¼
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	108	107⅜
200,000	100	5%	Do. 5 per Cent. Debentures, 1899 xd	106 109	4 11 9	February & August	107	...
250,000	10	2/6	Eastern Extension	12⅞ 13⅛	4 19 1	Jan., Apr., July, Oct	13 1/16	12⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891 xd	102 104	5 15 5	February & August	103¼	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust xd	7 7½	4 16 7	Jan., Apr., July, Oct.	7 3/16	7
178,992	10	3/0	Do. 6 per Cent Preference xd	14⅜ 14⅝	4 2 1	" "	14 5/16	14⅜
150,000	10	5/0	Great Northern	14½ 15	3 6 8	Jan., July, and April	15⅛	14⅞
17,000	25	2/6	Indo-European	38 40	6 5 0	April and October	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
15,609	10	3/0	West African Telegraph	7 8	...		...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	101	100
80,000	10	6/0	West Coast of America	8⅜ 9¼	6 9 9	January and July	9 1/16	9
150,000	100	8%	Do. Debentures 8%	117 121	6 12 3	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜ 1⅞	...		...	...
34,563	10	12/0*	Do. 1st Preference 6%	11½ 11⅝	5 2 2	April and October	11⅝	11⅝
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...		...	...
45,181	15	6/0	Western Brazilian	12⅞ 13⅛	...	March & September	13⅛	12⅞
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅝ ¾	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	7/16 9/16	3 2 11		...	...
80,000	5	5/0	United	14⅞ 15	5 0 0	June and December	14⅞	14½
55,000	5	3/0	United River Plate	5½ 5⅝	...	January and July	5 1/16	5⅛
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3¼ 4	...		3⅞	3½
23,692	5	2/0	Do. (fully paid)	4½ 5	...	February & August	4½	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅜ 2⅝	...		...	...
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	12/0	Telegraph Construction and Maintenance	42 43	5 11 7	March and July	43	42½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17½ 18¼	5 11 1	February & August	18¾	18¼

* Account arrears. † No dividend since May, 1880.

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NOTES.

The judgment in the appeal case of Edison-Swan *versus* Holland and Others (Anglo-American Brush Company) will be delivered on Monday morning next at 11 a.m.

The Friday evening lecture at the Royal Institution was last week delivered by Sir William Thomson, who chose for his subject "The Electrostatic Measurement of Potential." After describing the several instruments and methods with which electricians are already familiar, Sir William exhibited a new low-reading electrometer based upon the same principle as the electrostatic voltmeter which was first described before the Glasgow Philosophical Society, in April, 1887 (see *The Electrician* of April 29th, 1887, p. 542). The range of this instrument extended from 400 volts to 10,000 volts, whereas the instrument now exhibited had a range of from 40 to about 120 volts. These two instruments, in fact, belong to an entire series of electrometers upon which Sir William Thomson is now engaged, and which will measure by electrostatic force potentials of from 40 volts to 50,000 volts. The standardisation of these instruments up to 200 or 300 volts is made exceedingly easy, by aid of the centi-ampere balance, with a battery of any kind, capable of giving a fairly steady current of one-tenth of an ampere through the balance and a platinoid resistance in series with it. The accuracy of the electromagnetic standardisation, within the range of the direct application of this method, is quite within one-twentieth per cent. A method of multiplication by aid of condensers, which was explained, gives an accuracy quite within one-fifth per cent. for the measurement of E.M.F. up to 2,000 or 3,000 volts; and with not much less accuracy, by aid of an intermediary electrometer, up to 10,000 volts. Such a potential as 10,000 volts is convenient for measurement by an absolute electrostatic balance, which was fully explained by the lecturer and illustrated by a drawing, but hitherto he has not been able to make sure of the absolute accuracy of this electrostatic balance to closer than one-half per cent. The results of a great number of measurements made in the Physical Laboratory of the University of Glasgow during the last two months, give the required number, commonly called "v," within one-half per cent. of 300,000 kilometres per second. It is well known that the number of electrostatic units of potential force in the electromagnetic unit of potential is essentially a velocity. Experiments have proved it to be so nearly equal to the velocity of light, that, from all the direct observations hitherto made, we cannot tell, said Sir William, whether it is a little greater, or a little less, or absolutely equal to the velocity of light. The velocity of light is known to be within one-quarter per cent. of 300,000 kilometres per second. Results of previous observers for determining "v" had almost absolutely proved for "v" at least as close an agreement with the 300 million metres as this. Sir William expressed his obligations to his assistants and students in the Physical Laboratory of Glasgow University, Messrs. Meikle, Shields, Sutherland, and Carver, who worked with the greatest perseverance and accuracy in the laborious and often irksome observations by which he had attempted to determine "v" by the direct electrometer method as exactly as, or more exactly than, it has been determined by other observers and other methods.

We publish this week an abstract of a very elaborate Paper by Dr. A. Von Waltenhofen in the *Centralblatt*, on the measurements of the insulation resistance of the wiring of the new Court Theatre, Vienna. From the care and skill which was evidently exercised the results obtained should be of a trustworthy character, and as such they are of value in helping to determine a reasonable value for the insulation coefficient. Taking the simplest, and what is probably the most satisfactory expression, $R = k\,E/C$, where R is the insulation resistance and C the total current, the final results obtained would correspond to a value of k somewhat exceeding 20,000, and therefore actually higher than any figure which has yet been proposed. The test, moreover, was taken with all lamps and fittings in place. On the other hand, this high standard of perfection was only attained after a careful series of tests on each individual lead, followed by the elimination of all wires whose insulation resistance was less than 0·1 megohm whatever their length.

Referring to our remarks in the last issue on the advantages of testing for insulation resistance under an E.M.F. at least as high as that at which the installation will be worked, Prof. Jamieson raises the objection that such treatment has a tendency to "break down" an incipient fault. But surely this is an argument which tends altogether the other way; the very object of the test is to discover faults, incipient or otherwise. If it is preferred to allow a fault to develop under the action of the normal current, what is the use of the test? On the other hand, we can sympathise with the feelings of a contractor when the existence of a fault has been discovered which it may take days or weeks to localise. It is

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just this difficulty of localisation which induces many people to doubt the utility of insulation tests. But if a test be made it would seem better to make it a real test, and not an empty ceremony.

RETURNING to the question of incipient faults on installation wires we should be glad to ascertain whether it is actually a fact that they can, as a rule, be "broken down" by the application of a high E.M.F. The conditions of an electric light conductor do not readily admit of comparison with those of a submarine cable. It was owing to some uncertainty on this point that we last week suggested that it might be advantageous to keep a moderately high potential on the wire for some time before making the test.

STILL another claimant to the honour of the discovery of the principle of constant-current regulation by means of steam pressure has appeared in the person of Mr. J. KIRKHAM, whose claims are put forth in a letter from Messrs. JOHN SMITH and Co., of Moscow, which will be found elsewhere in this issue. It would, therefore, appear that there have been at least four separate and independent discoverers of this principle. However, we take this opportunity of stating that from facts which have come to our knowledge since our last reference to the subject, we are satisfied that the earliest observation of the principle was that of Mr. EDMUNDS himself in 1878. Mr. BERNSTEIN was perhaps the first actually to employ the device in this country, but Mr. KIRKHAM seems to have forestalled him in Russia by some three years.

ONE or two recent shipping disasters which have occurred on the western and south-western coasts are again directing local attention to the subject of connecting all the Coastguard Stations with each other and with the outlying lightships by telegraph or telephone wires. The Lifeboat Stations were in these instances at fault as to the real locality of the distress signals, and the crews of the ships perished in consequence. Electrical coast communication, it is said, would have notified the exact positions, and these lives might have been saved. The *Western Morning News*, we are glad to notice, is taking this matter up warmly, and petitions are being prepared praying that the Board of Trade or the Post Office may be allowed to establish the much needed cordon of electrical communication, on grounds both of humanity and of national safety.

THE theory of hempen-covered submarine cables seems to be finding favour in America as well as in some quarters nearer home, its advocates apparently relying on the fact that iron as a protector is corroded by the action of the sea, whereas hemp is unaffected by it. There are, however, other means of effectually overcoming this difficulty. Nor is this the only action that has to be guarded against. There are various species of teredo which attack the cables, and some of these marine parasites have a special fancy for hemp. Cables have been recovered from depths of twelve hundred fathoms with all the hemp eaten away. Again, it is a mistake to suppose, as does the writer in the Halifax (N.S.) *Chronicle*, from whom we quote this week, that once at the bottom of the deep sea the cable rests in undisturbed security. As a matter of fact, many localities are known to be liable to great disturbance from strong currents, and probably there are many more that we know not of. At least one cable has been destroyed in that way, although submerged at a depth of five hundred fathoms. On the other hand, it must be conceded that the absence of the iron sheath should tend to facilitate higher speeds of working.

AN ingenious system of multiplex telegraphy has been worked out by Lieut. PATTEN. In the systems at present in vogue synchronism is obtained by devices which are primarily of a mechanical character. Lieut. PATTEN has made a new departure, availing himself of the property of synchronism possessed by an electric motor supplied with alternating currents.

IN a recent number of the *Telephone* Mr. A. R. BENNETT records the interesting fact that he has found that looped metallic circuits are more liable to suffer from lightning discharges than single wires earthed at both ends. This is evidently an illustration of the "surging" or "resonant" effects discovered by Dr. LODGE, and the observation affords one more illustration of the general correctness of the theoretical views to which he has been led.

EVEN in the case of a non-oscillatory discharge we are not clear that the question, "which way the lightning went?" has any definite meaning. Mr. BENNETT, however, seems to think that it can be answered, when a spark to an earth terminal occurs, by observing on which side the greater heat effect has taken place. This we do not understand.

MR. SYDNEY EVERSHED complains that two "globular lightning" stories in one number of *The Electrician* is more than he can conveniently digest, especially as he firmly believes them all. But if Mr. SYDNEY EVERSHED only knew how many such stories we do not insert he would be the first to appreciate our moderation. In proof thereof we may cite a remarkable experience which happened in the South of France last year to a German Doctor of Divinity. This story has never before appeared in print; it came to us some weeks ago at second hand only, and under circumstances which render it at least as convincing as Mr. EVERSHED'S own assertion that "once he almost saw a fireball himself."

A TERRIFIC storm was raging, the Doctor had flattened his nose against the window pane, and was endeavouring by the well-known cardiacal method to estimate the distance of the storm centre, which seemed perilously near. Suddenly he was startled by the apparition of a vivid but persistent light, together with an uncomfortable sensation of heat in the facial region. At the same moment he became conscious of the fact that, despite his sudden impulse to retreat, he was absolutely unable to withdraw his nose from the pane against which it was flattened. By this time his vision had adjusted itself to the existing degree of brilliancy, and what was his horror as the conviction gradually stole over him that a fireball had attached itself to the window

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pane, and was indeed virtually hanging from the tip of his nose, with nothing but the dielectic between! In this appalling situation the Doctor remained, expecting every moment to be his last, for a space which seemed, he says, two hours, but which, on a calmer estimate, he has since reduced to two minutes. At length the electrostatic pressure on the tip of his nose commenced perceptibly to diminish, and he presently had the inexpressible satisfaction of seeing the "globular" glide slowly away; and almost immediately after it burst with a loud report, tearing up the ground over a space of several feet, quite in the orthodox manner. It is painful to reflect that so magnificent an opportunity for the extension of our knowledge has been thrown away on a Doctor of Divinity. Had Dr. LODGE or Dr. HERTZ been the victim, science would have been enriched by a monograph of the utmost interest and value.

WE are glad to be able to announce that the ELECTRICAL TRADES DIRECTORY AND HANDBOOK, which is compiled and published at this office, is now ready for the current year. It is the seventh year's issue of this useful volume, and it has now reached the respectable dimensions of six hundred pages, crowded with information either indispensable or extremely valuable to all persons engaged in the electrical and allied trades.

St. Martin's-in-the-Fields Vestry.—The consent of this Vestry was given last week to the House-to-House Company's Provisional Order.

Italian Cables.—The Minister of War has decided to have a cable laid from the Island of Maddalena to the mainland. The contract has been given to an Italian firm.

Royal Society.—An important Paper was read yesterday before the Royal Society by Dr. John Hopkinson, "On the Magnetisation of Iron at High Temperatures."

Portrait of Major-General Webber.—Our contemporary, the *Municipal Review*, published last week an excellent "ink-photo" portrait of Major-General Webber, C.B.

Exeter.—The Exeter Electric Light Company has purchased the "Rockfield Hat" block of buildings in New North-road, and machinery is to be erected at once for the supply of private houses in the city.

Barcelona.—The *Boletin Oficial* of the 7th inst. states that on the 19th inst., at 2 p.m., tenders will be accepted at the Central Telegraph Station of Barcelona for the establishment and working of a telephone system at Manresa.

Chelsea Vestry.—At a meeting of this Vestry last week permission was given to the Chelsea Electricity Supply Company to lay down an iron pipe to convey water from the Sloane-square railway station to their central station in Draycot-place.

An Electric "Star."—The paper-distributing carts of the *Star* are now illuminated by electricity. The light is a ten candle-power incandescent, run off an accumulator. The apparatus was provided by the United Electrical Engineering Company.

Important Sale of Electrical Apparatus.—It will be seen by our advertisement columns that Messrs. Wheatley Kirk, Price and Goulty have been instructed to sell at an early date the entire electrical apparatus belonging to the Electric "Sun" Lamp and Power Company, now in liquidation.

Strand District Board.—Applications from the Electrical Power Storage Company and from Messrs. Hill and Co., on behalf of Mr. Koerber, asking for the Board's support of their applications for Parliamentary powers, were read at a meeting last week, and referred to the Electric Lighting Committee.

Laxton's Price Book 1889.—The 1889 edition of this useful work, although some twenty pages smaller than that of last year, contains as usual an immense amount of valuable information. Eight pages of small type are this year devoted to electric lighting instead of less than six. There is, however, plenty of room for more detailed information under this heading.

"Some Curiosities of Magnetism."—Under the above title a most interesting address was delivered at the London Institution on Monday last by Mr. Shelford Bidwell, F.R.S. Although intended mainly for a popular audience, and couched in an eminently intelligible and "popular" vein, Mr. Bidwell's address and experiments could scarcely fail to have interested and instructed even a highly technical audience.

English Plant on the Continent.—In spite of the natural preference which is generally shown on the Continent for home-made machinery English plant often carries the day. As an instance of this we may mention that Mr. Albert Dawson, of Lille, has recently completed an electric light installation at the works of M. Léon Olivier at Roubaix, in which Kapp dynamos made by Messrs. W. H. Allen and Co. are used, as well as Cockburn cut-outs.

Electric Lighting in Liverpool.—The Watch Committee have had before them a letter with reference to the application of the Liverpool Electric Supply Company for the consent of the Corporation to apply for a Provisional Order, in which it was stated that the company are prepared to submit to a purchase clause, exercisable at the end of twenty-five years and at the end of every succeeding term of seven years. It was resolved that consideration of the matter be postponed for a month.

Institution of Electrical Engineers.—A students' meeting of the above Institution was held on Friday evening, February 8th, Mr. J. Rance, jun., Assoc. Inst. E.E., in the chair. A Paper was read by Mr. T. L. Horn on "Insulation Resistance and some of the Practical Difficulties in obtaining good Insulation on Electric Light Circuits." A discussion followed, in which Messrs. G. H. Nisbett and R. W. Paul took part, after which Mr. Rance made a few remarks, and a vote of thanks to him closed the proceedings.

The Snowstorm.—The snowstorm of the 10th inst has done very little damage to the telegraph and telephone lines in this country, owing, no doubt, to the fact that the flakes fell in a dry, powdery condition. On the Continent, however, the lines have been greatly interrupted, especially in France, Germany, and Belgium. In Germany, however, the breakdown caused little inconvenience, the underground system being now so complete that almost all the chief towns in the Empire maintained their telegraphic communication uninterrupted.

The Ward Electrical Omnibus.—This omnibus made two runs on Friday last. On the first trip it left the depôt and made a long run of about 7½ miles through the City and back. The second run was made through some of the busiest streets in London, right in the thick of the forenoon traffic. The omnibus left the depôt about 9:30, went up Regent-street and Portland-street on to the Marylebone-road, along Edgware-road to Westbourne-grove. The car then ran on to Paddington Station, back again down Edgware-road, Oxford-street, Grosvenor-square, coming down Regent-street through the ordinary thick daily traffic. The length of the second run was about 8 miles.

Multiplex Telephony on Long Lines.—Mr. D. S. Sinclair, engineer to the National Telephone Company, lately read a Paper on this subject before the Glasgow Philosophical Society. The lecturer described his Paper as a *résumé* of what had been done, and what was likely to be done, in regard to this subject. He showed that in no way could multiplex be done on single wires as such, but by employing return loop circuit wires three sets of telephones could be used on two such circuits. In America four sets of instruments on two circuits had been tried, but this the lecturer condemned, holding that that system destroyed the qualities of loop circuits, while using three sets retained them.

Exports of Telegraphic Wires and Apparatus connected therewith.—The year has opened with a very satisfactory improvement in our exports under this head. The following com-

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parative figures of the exports last month are taken from the Board of Trade returns. We add the aggregate figures for the previous 12 months :—

	1886.	1887.	1888.
Year	£992,667	..... £817,385	..... £521,174
	1887.	1888.	1889.
January.....	£14,442	..... £41,231	..... £113,230

The shipments last month must evidently have included some large items of an exceptional character.

Drake and Gorham's Catalogue.—Messrs. Drake and Gorham have just issued a new edition of their illustrated catalogue and price list. This publication is very complete, and contains quotations for the principal apparatus likely to be required by anyone contemplating an installation of accumulators. Amongst other things we notice Messrs. Drake and Gorham's "disc" ammeter, which seems a cheap and simple instrument, and a very useful table, which gives at a glance the type and number of cells required for a given number of lamps, with total price of the same. Messrs. Drake and Gorham have also issued some new working instructions, which furnish all sorts of practical hints in a small space, and which must prove of great assistance to those in charge of accumulators.

Absolute Resistance of Mercury.—In a recent number of *Wiedemann's Annalen* F. Kohlrausch publishes an account of a redetermination which he has carried out with elaborate precautions of the absolute resistance of mercury. The method employed was Weber's method of damping, with some slight modifications due to Dorn. The result arrived at is that the resistance of a cubic centimetre of mercury at 0°C. is 94,060 centimetre seconds. In order to compare this determination with the B A. unit, Mr. Glazebrook has compared one of the author's mercury standards with the B.A. unit in the Cavendish Laboratory, and finds that according to Kohlrausch's determination one B.A. unit = 0·9866 ohm. This would give a length of between 106·2 and 106·3 for the column of mercury one square centimetre in section having a resistance of one ohm.

Society of Arts Motor Competition.—The Council of the Society of Arts, on the award of the judges, Prof. A. B. W. Kennedy, F.R.S., Dr. John Hopkinson, F.R.S., and Mr. Beauchamp Tower, have awarded a Society of Arts gold medal to each of the following competitors :—Class A.—Motors in which the working agent is also produced—Davey, Paxman and Co., Colchester, eight horse-power compound portable engine. Class B.—Motors to which the working agent must be applied : 1st. Motors under ten horse-power (actual)—British Gas Engine and Engineering Company, Albion Works, Gospel Oak, six horse-power nominal Atkinson's "Cycle" gas engine ; 2nd, motors over ten horse-power (actual)—Crossley Brothers (Limited), Manchester, nine horse-power nominal "Otto" gas engine ; 3rd, Dick, Kerr and Co, Leadenhall-street, E.C, eight horse-power "Griffin" gas engine.

Barnet.—At the last meeting of the Barnet Local Board the clerk reported that, in accordance with the instructions of the Board, he had written to Messrs. Joel, inquiring the cause of a recent failure of the electric lamps. With reference to the actual cessation of light, Messrs. Joel replied that they were reluctantly compelled to attribute the failure to the breaking of the circuit through wilful mischief. They had endeavoured to ascribe previous difficulties to accident ; but could no longer refrain from saying wilful mischief was the cause, the wire at one of the lamps being severed and twisted up over the lamp. No discussion took place on the letter, as the whole question will be considered on the receipt of a report on the electric lighting of the district from the expert engaged by the Board. On the 6th inst. there was another breakdown of the electric light, and the town was in darkness for three hours. This is the fifth total failure in five months.

The Progress of the Telegraph and the Telephone.—The *Journal Télégraphique* contains some interesting figures relating to the progress of telegraphy and telephony during the past year. Since 1887 the number of telegraph offices, including those in the United States, has increased by 7,200 ; and during the year Germany opened her 10,000th office. Telephony has also made considerable progress. In the United States there are at present 750 systems and 200,000 subscribers. In Europe Germany leads the way with 167 systems and 26,000 subscribers ; England comes next with 125 systems and 20,000 subscribers ; then follow Sweden, with 150 systems and 15,000 subscribers ; France with 39 systems and 10,800 subscribers ; Italy, with 49 systems and 9,600 subscribers ; Switzerland, with 71 systems and 8,000 subscribers ; Russia, with 36 systems and 7,600 subscribers. In March, 1888, Germany possessed 148 inter-urban trunk lines, while in Belgium and Switzerland all towns with exchanges are in telephonic connection with one another.

Incandescent Lamps for Army Signalling.—Some important signalling experiments were carried out at Aldershot last week in the presence of Lieutenant-General Sir Evelyn Wood and Colonel F. C. Keyser, C.B., inspector of army signalling for the United Kingdom. The main object was to test a new signalling electric hand lamp made by Messrs. J. P. Rees and Co. The flashes are caused by the making and breaking of contact between the battery and the lamp, and they are for all practical purposes instantaneous. The lamp will burn from ten to twelve hours without having to recharge the battery. The night was far from being a satisfactory one for long distance signalling, being hazy and showery at intervals. Mr. Rees and party took up a position on Foxhills, near the Great Flash, a distance of about three miles. At this distance, except during clear intervals, the oil lamp could not be seen, or was only just discernible with the field glasses, whereas the electric lamp shone out clearly, and messages were transmitted with the greatest ease.

New Mexican Cable.—In our issue of 8th February we stated that a second cable was to be laid between Vera Cruz and Galveston. Later advices from Mexico bring some particulars of the undertaking, from which we learn that the new cable is to be used for the South American traffic, the present cable between Vera Cruz and Galveston being used exclusively for Mexican business. The Mexican Telegraph Company has arranged to lay the new cable in conjunction with the South American Telegraph Company, which has a line across the Isthmus of Tehuantepec. The increase in the South American business has become so extensive of late as to make it impossible to handle both that traffic and the Mexican business upon the present Mexican cable. The new cable will be laid from Coatzacoalcos, about 200 miles south of Vera Cruz, to Galveston, a distance of about a thousand miles. Advices from Mexico dated January 24th, announce the arrival of the steamer "Faraday" with the new cable, which is said to weigh about three tons to the mile.

Tenth Annual Exhibition of Meteorological Instruments.—The following circular has been issued by the Royal Meteorological Society :—"The Council of the Royal Meteorological Society have arranged to hold, at 25, Great George-street, Westminster (by permission of the Council of the Institution of Civil Engineers), on March 19th to 22nd next, an exhibition of *instruments connected with atmospheric physics* invented during the last ten years, especially those used for actinic and solar radiation observations. I am therefore instructed by the Exhibition Committee to invite your co-operation, as they are anxious to obtain as large a collection as possible of such instruments, &c. The committee will also be glad to show any *new* meteorological instruments or apparatus invented or first constructed since last March, as well as photographs and drawings possessing meteorological interest. Should you be willing to co-operate in the proposed exhibition I should be obliged by your furnishing me (*not later* than March 1st) with a list of the articles you will be able to contribute and an estimate of the space they will require.—(Signed) WILLIAM MARRIOTT, Assistant Secretary."

Halifax.—At the quarterly meeting of the Halifax Town Council last week several communications respecting electric lighting were read. Mr. Holroyd Smith wrote to the effect that if he received the support of the Corporation he would apply for Parliamentary powers and start a central station immediately. He further suggested that the Corporation should agree to take, say, 1,000 incandescents and 25 2,000 candle-power arcs to light the public buildings and main streets with.

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A subsequent letter was received from Mr. Holroyd Smith suggesting that in lieu of spending £30,000 on gasworks' extension, a scheme might be arranged for meeting the increased demand by electricity. On February 5th the Anglo-American Brush Corporation wrote to say that they had seen Mr. Smith's second letter, and they concurred with its contents. Messrs. Foster and England, solicitors, also wrote, presenting a memorial signed by several large tradesmen in the centre of the town, requesting the consent of the Corporation to their arrangements with the Schmidt-Douglas Company of Bradford, for the erection of a central lighting station. A letter from Messrs. Blakey, Emmott, and Co., was also read, asking for permission to run cables above and below ground from their proposed central station. A Mr. J. R. Smith wrote on the same subject, calling attention to his own views of electric lighting, which were submitted to the Corporation years ago, and offering his advice gratis in the event of the Corporation deciding to introduce the light into Halifax. All these communications were referred to a special committee.

The Telephone in Austria.—The Secretary of the Telephone Company of Austria sends us the following interesting extract from a letter recently received from their manager in Austria, Mr. R. H. Krause :—"In Czernowitz we have had a constant fight with the ice this winter. Ever since the New Year heavy damp fogs have come up the Pruth Valley, in Czernowitz the thermometer standing at 12·15° Reaumur. The result was that pure crystal ice up to and over half an inch in thickness was formed on the wires. We have so far succeeded in preserving the lines, never more than ten broken, which were at once repaired by the permanent staff in spite of the cold. Of course the heavy weight on the wires made many contacts, but we have managed up till now to keep matters going. In Graz we once had great danger from snow. The soft damp snow so dangerous to lines began falling at night. Here our instructions again worked well. Two town night watchmen receive annually a small sum and have the duty of informing our superintendent of storms of this specially dangerous snow. Thus within half an hour our men were out at all the dangerous spans knocking off the snow, and we succeeded in getting through that night and the next day with but one wire broken, and with an extra cost of about 10s. only for hot drinks for the men." The number of telegrams which passed through the hands of the company during 1888 in connection with the Austrian Government telegraph service was 110,843.

Anglo-German Telegraphs.—Herr von Stephan, Postmaster-General of the German Empire, stated in the Reichstag on Friday last that he had a gratifying communication to make with respect to the telegraphic intercourse between England and Germany. Hitherto there had been no direct connection between the telegraph systems of the two States, owing to the fact of the submarine cables being in the hands of private companies. But the concessions of these companies having lately expired, the two Governments took over the respective cables, with all their local belongings, and at the same time negotiations were entered into with Belgium and Holland, so that from the 1st of April next direct communication between Germany and England would be available by means of fourteen, instead of, as hitherto, only eight, lines, while at the same time the tariff for transmission would be considerably reduced. Hitherto, for example, the tariff to England had been a little more than 2d. per word, with an initial charge of 4d., but this latter was now to be abolished altogether, while the word-tariff would be reduced from 2d. to 1½d. Thus, for instance, a telegram of 12 words to England, which now costs a little more than 2s. 8d., would in future be sent for about 1s. 8d., implying a saving of 1s. on so short a message. "This gratifying result," said the Minister in conclusion, "we owe to the hearty co-operation of the English Government with that of Germany, and to the energy and intelligence of the higher telegraph officials in London and Berlin." We learn in this connection that Mr. J. C. Lamb, accompanied by Mr. H. C. Fischer, has just returned from the Continent having completed the necessary arrangements with the German, Dutch, and Belgian Governments, the final arrangements with France being still the subject of negotiation.

The Effect on Electric Lighting in the United States of the Bate Decision.—The opinion of the Supreme Court in the case of the Bate Refrigerating Co. *v.* Hammond and Co. is stated, says the *Electrical World*, to affect favourably, as regards prosecution of infringements, the following Edison electric light patents, upon which suits have been pending for some time against competing electric light companies, and the prosecution of which suits has been delayed up to the present time by the technical obstacle which the decision of the Supreme Court removes. Those patents are :—

No. 223,898, covering the broad invention of the filament lamp.
No. 227,229, covering the use of high-resistance enclosed conductor in a vacuum chamber entirely of glass.
No. 265.777, covering the perfection of the carbon filament in the driving out of the occluded gases in the vacuum by the heat of the current.
No. 265,311, covering broadly the employment of a lamp removable from the socket.
No. 251,554, on positive connection between the lamp and the socket, so that the position of the lamp can be reversed.
No. 230,255, on making the closed chamber of the lamp in two parts, fused together.
No. 266,447, on making the closed chamber of the lamp in two parts, fused together when the globe is made from pot blown glass.
No. 248,419 and No. 264,698, on details of glass construction.
No. 248,424, on providing a pendant incandescent lamp, removable from its socket, with a shade or reflector placed above it, so that the lamp can be moved and placed without disturbing the shade.
No. 263,140, covering the use of two or more commutator brushes.
No. 251,540, on making the filament of bamboo or other fibrous material, having the fibres running parallel throughout the length of the filament.

Suits on these patents are pending in the Circuit Court of the Southern District of New York against the United States Electric Lighting Company, the United States Illuminating Company, the Consolidated Electric Light Company, and the Swan Incandescent Electric Light Company. In addition to the above patents, the Edison feeder patent, No. 264,642, on which suit was brought *v.* Westinghouse, Church, Kerr, and Co., at Trenton, N.J., is also held to be affected favourably by the decision of the Supreme Court.

The Continental Cables.—The following statement has been circulated by the *Central News* :—"The English and French Governments have failed to arrive at an agreement respecting the purchase of the Anglo-French cables from the Submarine Telegraph Company. At the time when the British Government decided definitely not to renew the concession to the Submarine Telegraph Company it was understood that the two Governments should purchase the cables of that company at a valuation, and it is alleged that a promise was given by the British Treasury to that effect. The French Government, however, is now objecting to the purchase of these cables on any terms, on the ground that they are too old for satisfactory working, and that it would be preferable to lay new and better cables. Mr. W. L. Jackson, M.P., of the Treasury, and Mr. Patey of the General Post Office, went to Paris recently, and had prolonged conferences with M. Coulon, Minister of Posts and Telegraphs, on the subject, but without altering the opinion entertained by that gentleman. Since these conferences in Paris M. Coulon has sent engineers from France to inspect and test the submarine plant and cables, in conjunction with the English Post Office engineers. A thorough examination was made at Dover, as well as at East Dean, near Eastbourne, and as a result of these investigations, the *Central News* learns, reports have been forwarded to Paris which are by no means favourable to the purchase of the submarine cables. It is believed that the British Government will yield to the wishes of France in this matter, and that entirely new cables will be constructed for working between the two countries. It is somewhat significant, too, that although an agreement had been signed by Belgium and England for working the Anglo-Belgium cables, these have not yet been bought, nor has the British Treasury made any offer for them. It is probable that if new cables are laid between England and France, they will also be laid between England and Belgium. This new development of affairs is a hardship upon the Submarine Company, but it is difficult to see how, in face of the determined opposition of France, the cables of that company can be purchased by England."

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THE ELECTROLYTIC SEPARATION AND REFINING OF METALS.*

HISTORICAL SKETCH.

BY DR. G. GORE, F.R.S.

More than thirteen hundred years ago Zosimus mentioned the earliest known fact respecting the electrolytic separation of metals, viz., that by immersing a piece of iron in a cupreous solution it acquired a coating of copper. Ever since that time the same fact has been commonly observed by workers in copper mines, that their tools of iron or steel became coated with a film of copper by contact with the water percolating through the mines; the water holding in solution blue vitriol derived from oxidation of mineral sulphides of copper contained in the rocks. Paracelsus in the years 1493 to 1541, and even Stisser, the professor of chemistry in Helmstadt, as late as 1690, believed that by this process the iron was changed into copper.

The discovery of chemical electricity by Volta and the invention of the voltaic battery as an instrument for producing it did not occur until about the year 1799. Wollaston soon afterwards observed that "if a piece of silver in connection with a more positive metal be put into a solution of copper, the silver is coated over with copper, which coating will stand the operation of burnishing" (*Philosophical Transactions* of the Royal Society, 1801). About the same time Mr. Cruickshank passed an electric current from his voltaic battery through a solution of sulphate of copper, and found that the copper attached itself to the wire connected with the zinc end of the battery, and stated that the metal was "revived completely" (Wilkinson's "Elements of Galvanism," Vol. II., 1804, p. 54). In 1805 Brugnatelli also observed that when the current entered the liquid by means of a piece of copper, the copper was dissolved and then deposited upon the negative pole ("Annals of Chemistry").

In 1831 Faraday discovered magneto-electricity, or the production of electric currents by means of mechanical power acting through the medium of magnets, a discovery which enabled all the subsequent inventions and improvements in dynamo-electric machines to be made, and the refining of metals by electrolysis to become commercially possible on a large scale. When he made this discovery the electric current he obtained was so very feeble that he was barely able to detect it, and he remarked: "I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained, being assured that the latter would find their full development hereafter" ("Experimental Researches," para. 158). This prediction has since been abundantly verified.

In 1836 De la Rue observed that the copper deposited by the voltaic current in a Daniell's battery cell gradually became thicker, and might be stripped off in the form of a separate sheet of metal from the surface upon which it had been deposited. About the year 1839 Jacobi, of St. Petersburg, and soon afterwards Jordan, Spencer, and others, made and published their experiments on electrotyping in copper, and thus made the process of depositing that metal familiar to the public.

From that time until the present, copper has been constantly deposited on a commercial scale as a coating upon various articles of iron, &c., in order to protect them; the electrolytic process has also gradually extended and been employed to form ornaments and other articles, until at length copper of more than one inch in thickness has been deposited, and copper statues weighing several tons have been formed by the process. Electro-deposited copper has also been frequently analysed and found to be extremely pure—so much so, that it has been employed in the Royal Mint to alloy with gold in making the standard coins of this realm. Its deposition on a large scale and great degree of purity, thus foreshadowed the electrolytic refining process.

The first actual commercial application of electrolysis to the refining of copper is to be found in a patent (No. 2,838) granted to James B. Elkington (son of the late G. R. Elkington, the original patentee of commercial electro-silvering and gilding) Nov. 3rd, 1865, entitled "Manufacture of Copper from Copper Ore." In this process plates of crude copper are used as anodes suspended in "troughs charged with a nearly saturated solution of sulphate of copper," the cathodes or negative plates being formed "of pure copper, rolled very thin." As the crude copper dissolves, pure copper is deposited upon the negative sheets. The patentee proposed to use a series of depositing troughs, each containing a set of properly connected anodes and cathodes, the electrolysis being effected by a current obtained from a magneto-electric machine. The insoluble residue which falls from the anodes to the bottom of the liquid frequently contains "silver, some gold, and also tin and antimony."

In a second patent (No. 3,120), taken out by the same patentee, Oct. 27th, 1869, for the "manufacture of copper, and separating other metals therefrom," impure copper, and especially that which contains much silver, is cast with a "T-shaped head of wrought copper," to enable it to be conveniently suspended as a dissolving plate in the depositing vessel.

"These plates are placed in fireclay jars, ranged longitudinally in troughs on a slightly-inclined, pitched, and otherwise prepared wooden floor, in the dissolving-house. Each jar has a hole in the bottom, closed by a wooden plug, and two holes in the sides, one low down and the other on the opposite side near the top, each jar being connected with the next lower one by a pipe or tube passing from the higher hole of the one to the lower hole of the other jar. The liquid current thus established between the solutions effects mixture of the layers of different density, maintaining all the liquids in the series of jars practically alike at top and bottom, notwithstanding the disturbing influence of the electro-deposition, which constantly tends to produce inequalities of density.

"The solution made use of is water saturated with sulphate of copper, a store of which is kept in a tank at the upper part of the depositing-room, whence it is admitted into the uppermost jars, and runs from jar to jar till all are filled. A solution may also be used obtained by boiling the deposit formed in the culvert or long flue by which the smoke from the copper furnaces is led to the high chimney.

"The tubes connecting the jars have clips attached to their india-rubber portions, acting as stop-cocks. When needful the clips are removed, so as to cause the solutions to mix, the dense layer from the bottom of one jar displacing the lighter portion from the top of another, until the density throughout becomes equalised. The outflow is received in a tank at the lower end of the room, from which it is pumped back to the upper reservoir. The plugged holes at the bottom of the jars enable the latter to be emptied on to the inclined floor, the liquid then flowing into the lower tank. The T-shaped heads attached to the plates enable them to be suspended in the jar, from horizontal copper bars having forks upon them. Interposed between the copper plates to be dissolved are suitably-suspended receiving plates for the deposit of the electrolytic copper. The receiving plates of one jar are connected by a conducting strip of copper with the cast plates of the next jar, and so on throughout. The series being coupled up into a circuit, the terminals are connected with one or more magneto-electric machines. The silver originally contained in the copper of the plates set for solution separates as a sediment, and ultimately accumulates as a deposit in the tank below, after the repeated workings and emptyings of the jars.

"Ores rich in silver are preferred as the source of cast copper for this treatment, since the silver is obtained as a bye product, without increasing the cost of obtaining pure copper from the impure metal."

These two patents of Mr. James Elkington contain the essential parts of the process of purifying copper by means of electrolysis, viz., employing slabs or thick plates of the crude metal as anodes; a series of depositing vessels with the solution flowing slowly through the whole of them, in order to keep it uniform in composition; the use of electric currents generated by means of mechanical energy, and the collection of the valuable impurities in the form of a sediment at the bottom of the vessels. The only other essential circumstance remaining is that of the occasional purification of the electrolyte by evapo-

* Extracted by permission of the Author from a forthcoming work on this subject. This book will be published at the Office of *The Electrician*.

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rating it, and crystallising out of it the sulphate of iron and other soluble salts which gradually accumulate.

This process was developed and carried out on a large scale at Pembrey, near Swansea. The works at Pembrey formerly belonged to Messrs. Elkington, Mason and Co., but have since passed into the possession of the Elliott Metal Company (Limited), Selly Oak, near Birmingham, and at the present time this refinery is one of the largest and most perfect existing.

Meanwhile, *i.e.*, during the gradual extension of electro-deposition of copper, the originally minute, but, nevertheless, extremely important fact and phenomenon, of the production of an electric current by mechanical energy acting through the medium of magnetism, was developing slowly. This phenomenon when first discovered by Faraday in 1831 was so small as scarcely to be perceptible, and was first observed by him as "a sudden and very slight effect at the galvanometer" (Faraday's "Experimental Researches," Vol. I., p. 3). No sooner had Faraday published this seemingly unimportant effect than various experimentalists endeavoured to obtain it upon a larger scale. Prof. Forbes, of Edinburgh, Nobili, Ritchie, and others, as well as Faraday himself, quickly succeeded in obtaining electric sparks by means of the magneto-electric current. In 1832 H. Pixii invented and exhibited at Paris the first magneto-electric machine, and decomposed water by means of the current from it; this was followed in 1833 by Saxton's improved machine, and by that of Clarke in 1836; and on August 1st, 1842, was granted to J. S. Woolrich the first patent, No. 9,431, for a magneto-electric machine for commercial purposes. Woolrich's machine was for a long time used by Messrs. Prime, of Birmingham, for electro-silverplating.

Since that time the improvements in producing magneto-electricity have been numerous. In 1857 Werner Siemens invented his shuttle-wound armature; in 1860 Pacinotti developed his ring armature machine for yielding a continuous current, which formed the basis of Gramme's and other direct-current machines. In 1866 H. Wilde further increased the power of the apparatus by using a soft iron electro-magnet instead of an ordinary steel one to produce the currents; in 1867 Siemens, Wheatstone and Ladd each separately observed the fact of self-excitation by mechanical power, and developed the self-exciting machine; and in 1871 M. Gramme produced the first practical continuous-current machine for commercial purposes. Alterations and improvements have since that time succeeded each other so rapidly that there exists now quite a large variety of machines for converting mechanical energy into electric current. The magnitude, weight, and speed of the machines have also increased, until there are some which require several hundred horse-power to drive them; others which weigh as much as forty-five tons each, and some with armatures revolving at a speed of nine thousand revolutions a minute. The efficiency of the machine has also been increased until as much as 96 per cent. of mechanical energy imparted to the armature is converted into electric power. With a single dynamo now as much as thirty tons of copper are deposited per week. Even now the limit has not been attained, or even conceived, to the magnitude and uses of the machine, and dynamos will probably yet be constructed equal in amount of energy to the largest steam engines, and their power be applied to a great variety of purposes, mechanical, thermal, and chemical.

At the present time the process of electrolytic separation and refining of metals is extending rapidly; it is carried on at Pembrey, Widnes, Swansea, Tyldesley (Lancashire), Milton (near Stoke-upon-Trent), Paris, Marseilles, St. Denis, Angoulême, Biache (Pas de Calais), Hamburg, Stolberg, Berlin, Moabit (near Berlin), Oker (in the Hartz), Eisleben, Burbach (near Siegen), Frankfort-on-the-Maine, Schaffhausen, Stattbergerhütte (near Cologne), the Koenigshütte (in Silesia), Witkowitz (in Moravia), Stephanshütte (in Upper Hungary), Brixlegg (in the Tyrol), Ponte St. Martino (in Piedmont), Casarza (near Genoa), Pittsburg (Pennsylvania), Milwaukee (Wisconsin), Bridgeport (Connecticut), Omaha (Nebraska), Ansonia (Connecticut), St. Louis (Missouri), Newark (New Jersey), Cleveland (Ohio), Longport (near New York), Santiago (Chili), Chihuahua (Mexico), &c. At Messrs. Balbach's Works, Newark (New Jersey), sixty tons of copper are deposited and refined per week. "Messrs. Bolton, at Widnes, and Messrs. Vivian, as well as Messrs. Lambert, at Swansea, are each depositing from forty to fifty tons per week, by currents from 5,000 to 10,000 amperes" (*Nature*, January 26th, 1888, p. 303). The "daily quantity refined at Oker is two and a-half tons; and the total amount in Germany and Austria is about six tons daily." Messrs. Elliott and Co., of Pembrey (near Swansea), deposit nearly the largest amount, forty-five to sixty tons per week, in this country. I am informed from a direct source that the Bridgeport Copper Company, of Bridgeport (Connecticut), electrolytically refine "one million pounds of copper per month," or about 108 tons per week, "by means of three dynamos."

REVIEWS.

Practical Electrical Measurements. By J. SWINBURNE. (London: Alabaster, Gatehouse and Co.)

This very interesting and useful book is mainly a reprint of a series of articles published in our contemporary, the *Electrical Review*. It deals with instruments and methods used principally in connection with heavy electrical engineering, and there is no doubt plenty of room for it, as, although the standard book of Kempe on electrical testing and other later works, notably, Ayrton's excellent "Practical Electricity," supply the wants of telegraph engineers and workers in laboratories, there has hitherto been no book exclusively devoted to the more ponderous branch of electrical measurement in the workshop and the dynamo room. Probably no better writer than Mr. Swinburne could have been chosen, for he combines in an uncommon degree practical experience and theoretical knowledge of almost every department of this subject. Anyone who knows Mr. Swinburne will be aware that he cannot be dull, and, as was to be expected, we find here and there in this book passages which will raise a smile, serious and solid as are the subject and its general treatment. One or two instances may be quoted. Thus, ". . . an installing engineer who would not scruple to dispense with a voltmeter and judge the electromotive force by the look of the lamps, searches for ground contacts with a forty-guinea bridge in conjunction with one defective Leclanché cell, and a pivoted detector which sticks." This type of electrician is, however, almost extinct; but unhappily the one referred to in the following explanatory paragraph still flourishes—the passage is taken from the preface:—"The writer has avoided using mathematical symbols, partly to make the book more readable, and partly with the hope of setting an example to others. The pedantic fashion of dragging mathematical symbols into all electrical literature, and the respect commanded by an analytical investigation, even on false data, often lead writers to mar work otherwise good, by getting out of their mathematical depths and writing nonsense to look learned."

The book is divided into 12 chapters, dealing with resistance, voltmeters and ammeters, their winding and calibration, wattmeters, recording meters, the testing of dynamos, motors, batteries, arc and incandescent lamps, mirrors, and lastly alternating currents. It is not too much to say that in the whole book there is not a paragraph that is not the result of careful and independent thought, and although one is sometimes disinclined to accept the author's conclusions, he is always suggestive and helpful. The first chapter, on resistance, contains an account of several useful methods of measuring very low resistances, such as low-tension armatures. Probably the best of these is a modification by the author of an arrangement by Heaviside or Kirchhoff, the galvanometer being differential; but the writer is inclined to agree with the author that in practice it is convenient to pass a fairly large current through the resistance to be measured, taking the volts and amperes. The new low-reading voltmeter of Ayrton and Perry should be found useful for such work, or a still newer instrument which Captain Cardew recently showed the writer. Perhaps one of the small instruments sold for testing secondary cells would answer the purpose. A hint may be given by the writer while on this subject. It is a very difficult matter to be sure of all the joint

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in an armature, but bad or indifferent joints may generally be discovered in low-tension machines by sending a current through the armature, and taking the fall of potential from sector to sector by means of any suitable sensitive galvanometer. Any irregularity is thus easily detected. Several special portable instruments for measuring resistances are described, suitable for rough work, but the "Universal" galvanometer of Siemens, which is perhaps the most sensitive of the portable instruments, is not referred to.

The only workers at that much-talked-of-but-little-used instrument, the ohmmeter, appear to have been Ayrton and Perry, Evershed and the author, to the first two of whom the idea of the instrument and the first example are due. Evershed has recently overcome, by an ingenious arrangement of the winding, what was a source of error in the principle of the ohmmeter as originally introduced, viz., that if it is joined up as a "short shunt" the shunt current goes through the series; while, if used as a "long shunt," the shunt is affected by the fall of potential due to the resistance of the series coil. A very good method of compensating for this error was first used by the author in a wattmeter, and is explained under that head.

On the subject of range and proportionality it is very properly pointed out that in instruments for special cases, such as for ordinary electric lighting work, the scale should be very open just where readings are wanted. This is a matter that makers would do well to attend to. Thus, for ordinary 100-volt installations voltmeters are not wanted to read less than 90 volts (except, perhaps, on the Grosvenor Gallery circuits), or more than 110, and the scale should be made as open as possible over that range. The author thinks—and gives his reason for thinking—that when an instrument has its scale marked off into equal divisions it must be regarded with suspicion.

Under voltmeters and ammeters the principles involved in the various types are discussed, and descriptions and illustrations of a large number are given. The excellent instrument of Raworth, made by Siemens Bros., which is supplanting the Siemens dynamometer for direct-current work, is not mentioned; probably it was scarcely known when the article was written.

In voltmeters for alternating currents there has hitherto been only that of Cardew, as electrometers have not come into practical use for high E.M.F.s, and have not been available for low E.M.F.s. There is likely to be a great improvement in this direction, as the new multi-cell electrometer of Sir Wm. Thomson, described by him last week at the Royal Institution, promises to be a most useful instrument, both for direct and alternate currents. For the latter it will be very useful. The Cardew voltmeter, though a most ingenious and valuable instrument, has the disadvantage of taking a good deal of power. The author states that the instrument to read to 120 volts takes 40 watts at that E.M.F. This is a very serious consideration, and in continuous use would cost the consumer on an ordinary central station system £8 to £10 per annum for power, as it would take nearly one (old) Board of Trade unit per day. The 120-volt instruments take rather less than 30 watts at 100 volts. This is not so much as that cited by the author, and there is little doubt that it will be found possible to make the instrument much more economical of power.

Recording meters have a chapter to themselves. The electrolytic meter, so largely used in the United States, is adversely criticised. The general opinion in this country is, with the author, opposed to their use on parallel systems, principally on account of the loss in the resistance used in the lamp circuit in connection with them and the variations of light resulting therefrom. But this cannot be as serious as is supposed, or the principle would not have been so extensively applied. On this point the recent Paper by Mr. Jenks is silent.

Faure's meter is described. It was the first of the Faraday disc or, rather, Barlow wheel meters, and, if we recollect rightly, it was in Faure's specification that the statement was first made that the torque varied as the square of the current and the friction as the square of the speed, so that the speed was as the current. This sounds so satisfactory that it has been generally accepted in connection with all meters having vanes, but we now know it to be incorrect. Probably no one but Mr. Ferranti knows how much labour is necessary to make a meter of this type practical. Ayrton and Perry's clock meter is described, and Aron's modification thereof, and a good figure is given of Forbes' ingenious windmill meter.

Of recording meters for alternate currents little or nothing is said; they scarcely existed when the book was written.

The long and instructive chapters on the calibration of voltmeters and ammeters must be passed over.

A good deal of useful information is given on the testing of dynamos and motors, but the writer must object to the author's remarks on what he considers the harmful custom of making slow-speed dynamos. Much that he says is right, but it is not right to take the output of a dynamo as directly proportional to speed, and internal losses as constant. As a matter of fact, the output of a dynamo does not (or should not be allowed to) go up as the speed, and the losses are not constant at all speeds, as the author assumes. The last chapter is on "Alternating Currents," and it will repay careful study. A strong protest is made against the custom of considering, for convenience of mathematical treatment, that all dynamos give sine curves, or that even if they are not so obliging, that there are properties in a system of converters which reduce the curve to a sine curve. While agreeing that the curve of a machine depends upon what is going on in the external circuit, an objection must be made to the following passage:—"If the dynamo is feeding 100 transformers, each at half load with the iron not saturated, the curve will not be the same as when it feeds 50 fully-loaded transformers with cores highly saturated at each extreme." As a matter of fact it is not usual for transformers to be designed with such conditions as regards their saturation. In his recommendations in connection with alternate-current measurements considerable use is made of an imaginary wattmeter without self or mutual induction. If such an instrument existed it would undoubtedly be very useful, but as it is not at present available its use on paper is only of advantage in considering what it is we want to measure. This is a consideration that is of the very first importance, and the author lays stress upon the use of the wattmeter probably as affording the simplest means of explaining the subject, and his explanations are very clear. Altogether the book is an excellent one, the few points that have been objected to in this notice being almost the only ones that out of a large mass of matter have struck us as perhaps open to criticism.

"The Electrician" Electrical Trades Directory and Handbook for 1889 (*The Electrician* Printing and Publishing Company (Limited), 1, Salisbury Court, Fleet-street, E.C. Price 3s. 6d., postage extra.)

This exceedingly comprehensive and useful Directory, which is issued from the press of *The Electrician*, has this year taken up a foremost place among trade handbooks of this kind. The Directory sections have been greatly enlarged and more carefully classified, and further additions made to the Biographical section. Numerous tables have been incorporated bearing upon subjects of importance to all branches of electrical trade; besides many new features of more general commercial interest.

REPORT ON THE INSULATION MEASUREMENTS MADE ON THE ELECTRIC LIGHTING INSTALLATION IN THE NEW COURT THEATRE, VIENNA.*

BY DR. A. VON WALTENHOFEN.

During the building of the new Court Theatre at Vienna I received instructions to thoroughly test the insulation of the various leads and cables while the installation work was still in hand. One of the chief reasons for this work was the idea that the building being constructed to so great an extent of iron would be very prejudicial to so extensive a system of wiring as exists in this theatre. Another reason, however, was that the newspaper reports which appeared when the much-to-be-regretted breakdown occurred in the opera lighting (although this breakdown was entirely due to the faulty boilers, and was in no way whatever attributable to any electrical causes) led to a report being circulated to the effect that the cables and leads in the opera house were defective, and fears were entertained that similar defects might appear in the installation in the new Court Theatre, which was already in progress.

* Abstracted from the *Centralblatt für Electrotechnik* by R. H. Krause.

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Under these circumstances it was considered advisable to test this installation in a systematic and thorough manner, so that a reliable and unprejudiced opinion might be obtained as to its efficiency, and that any faults might be at once discovered and rectified.

Before referring to the measurements themselves, I will give a short description of the installation, the details of which have been kindly communicated to me by Mr. T. W. W. Melhuish, Assoc.M.Inst.C.E., the chief engineer of the Electrical Department of the Imperial Continental Gas Association.

The central station which the I. C. G. A. has erected is situated only a short distance from the Hofburg Theatre in the Shenkenstrasse, No. 10. In it are eight boilers (Babcock and Wilcox) which supply steam to eight combined steam dynamos, five of these being of 130 and three of 170 horse-power, the former yielding 130 amperes × 540 volts, and the latter 250 amperes × 400 volts. The different voltage of the machines is due to the different arrangements of batteries in the two theatres, four being placed in series in the Opera House, while in the Burg Theatre only three are used in series; this will, however, soon be altered.

The central station is connected by means of underground cables with both theatres, and in the cellars of these are placed the accumulators, in each over 100 tons of plates, so that this is the largest installation of the kind in existence.

In the Hofburg Theatre the accumulators in use were manufactured at Baumgarten, near Vienna, in the factory of Messrs. Getz and Odendall, who are working under the patents of Farbaky and Schenek, and of the Electrical Power Storage Company. Each cell is composed of three sections of plates, and weighs altogether

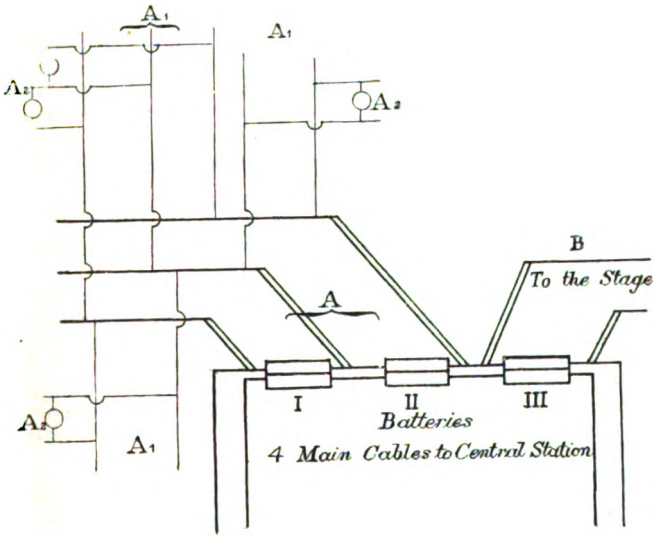

FIG. 1.

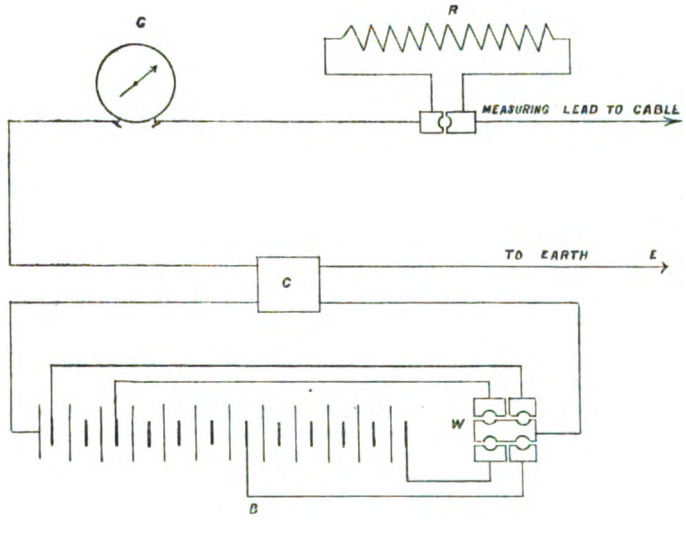

FIG. 2

nearly 300 kilometres. 486 such cells are divided into three batteries, Nos. I., II., III. (Fig. 1), each battery being again subdivided into three series, consisting of 54 cells; there are, therefore, in all nine series of 54 cells each. In this number are included the regulating cells, which are added as required by the fall of potential: this regulation is effected by means of a complete apparatus designed by the engineer of the I.C.G.A.

Battery No. III. is specially for the stage lighting on the simple parallel system B, while the batteries I. and II. are used for the remainder of the house, and all are arranged in connection with a three-wire system, A. These three batteries alone (*i.e.*, without current from the machines) are sufficient to maintain 3,600 lamps of 16 nominal candle-power for six hours. Thr e of Dr. Aron's latest type of electricity meters, one for each battery, register the quantity of current used. The current after passing the meters is conveyed by means of massive cables to the distributing room, and these cables are here connected to the copper bars of the main switch-boards. The different house circuits all start from these boards, each being provided with a switch and double fusible cut-out. To the above-mentioned three-wire system belong 94 leads, and these I have termed distributing leads of the first order, the branches from these distributing leads of the second order, and from these latter are taken the leads to single lamps. The cables which belong to the first order are marked A_1, those to the second order A_2. The total length of leads in the system is about 110 kilometres, and on these are 5,300 incandescent lamps, varying in power from 10 to 40 candles, also 15 arc lamps for the stage and exterior of the theatre.

The auditorium is lighted by means of a magnificent lustre containing 370 lamps and by 16 sun burners; the *foyers*, corridors, and staircases have 1,800 lamps; dressing rooms, &c., 800; while for the stage 1,970 lamps of 25 candle-power are in use. A very complete stage regulating apparatus, constructed by the Allgemeine Electricitäts Gesellschaft in Berlin, allows all the light effects required on a large stage to be produced, including, by means of coloured lamps, sunrise and sunset scenes.

The accumulators in this theatre being sufficient in themselves to supply the current required for a performance gives a security and convenience to the public (in the improbable event of all the machines breaking down) which no other theatre in the world can offer. This magnificent installation does the greatest credit to the Imperial Continental Gas Association and to its engineers, Messrs. Melhuish, Sechehaye and Gardy.

A well insulated wire was permanently laid from the testing room on the ground floor (where the instruments were set up) through the cellars to a point situated as nearly as possible in the centre of the building. From this point the wire was conveyed each time to the portion of the cable under examination by means of a portable reel. The total length of the testing wire was 400 metres; it was a copper wire insulated with gutta-percha and double-cotton covered.

Telephonic communication was established between the test room and the point where the measuring wire was connected to the cable. Finally, an earth wire was brought into the measuring room.

As galvanometer, I selected, with most satisfactory results, the Weinhold mirror galvanometer. I used in most cases 12 well insulated Siemens cells, and for some measurements a chloride of silver battery.

In the accompanying diagram (Fig. 2) the galvanometer is marked G, the battery B. With the help of the switch W, either 1, 3, 6 or 12 cells could be used as required. A commutator, C, allowed the positive pole of the battery to be connected with the galvanometer G, and the negative with the earth wire E, or *vice versâ*.

The second terminal of the galvanometer G remained always in connection with the measuring wire leading to the cable under examination, the withdrawal of a plug allowed a large resistance, R, to be inserted between the galvanometer and the measuring wire. The galvanometer had a resistance of 960ω. I also made use of Siemens and Halske's graphite resistances, one having $5 \times 200{,}000$ ohms, the other with graduations, three of 10 million, one 20 million, and one of 50 million, making together 100 meghoms.

It was ascertained by preliminary experiments how many degrees the Weinhold galvanometer registered if resistance to the amount of 1 megohm was placed in circuit with it. Let s be the number of degrees shown, and n the number of cells in use. If on again connecting the resistance to be measured, x, the degrees shown are s_1, while n_1 cells are employed, the resistance is

$$x = \frac{n_1}{n} \cdot \frac{s}{s_1} \cdot 10^6 \quad \ldots \ldots \quad (1)$$

that is

$$\frac{n^1}{n} \cdot \frac{s}{s_1} \text{ megohm.}$$

The measuring battery did not remain constant, so that these preliminary experiments had to be repeated before each set of measurements was begun. We will here limit ourselves to accounts of averages given in round numbers. One cell of the battery caused a throw of nearly 4 degrees with the megohm resistance in circuit.

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As on the one hand one-tenth of a degree could be estimated (especially as the commutator was used each time), and as on the other hand 12 cells could be employed, it was possible to measure or rather estimate resistance to the extent of $40 \times 12 = 480$ megohms. If an insulation resistance was so great that no reading could be registered with certainty, even when the whole battery was employed (which was frequently the case), it could be assumed that the resistance must exceed 480 megohms. On the other hand, the smallest resistance that can be measured is 0·08 megohm.

Leads whose insulation was found to be below the above-mentioned limit were then tried with the insulation tester of Siemens and Halske; this is a magneto-inductor with handle combined with a vertical galvanometer. When the handle is turned at a certain speed the scale of the galvanometer indicates the ohms in circuit. This apparatus measures (approximately only, of course) from 70,000 to 10,000 ohms, but by its use a fault can be easily detected, as, in such a case, by turning the handle only slowly the pointer will be thrown entirely off the scale.

When, therefore, it became necessary to measure accurately resistances of less than 0·1 megohm, I used the Weinhold mirror galvanometer with a suitable shunt; this apparatus, however, was not required for single leads, but only when it became necessary to measure groups.

Single leads which showed a resistance of less than 0·1 megohm were noted as faulty, and pointed out to the engineers of the I.C.G.A. to be repaired or replaced.

Every measurement was begun with only one cell of the test battery in circuit in order to avoid damaging the galvanometer in cases where the insulation resistance was low. In order to entirely prevent such damage occurring a protecting resistance of 1 megohm (*see* Fig. 2) was also placed in circuit with the galvanometer; if then it was found that the reading was less than four divisions on the scale, this protecting resistance was plugged out and the number of cells increased as required.

The frequent appearance of faulty leads, even after the extreme care exercised by the Engineers of the I.C.G.A. in applying only the best material and workmanship, is not to be wondered at when one bears in mind, first, that I rejected as bad many leads which in other installations would have been passed as satisfactory. For instance, the Phœnix rules require for single leads an insulation resistance of 10,000 ohms, whereas I rejected all those which did not show at least 10 times this amount; secondly, the conditions under which the installation was made were unfavourable in this respect.

It was necessary to lay several leads in damp walls, and these gave great trouble later; others were removed at my request because they were, in accordance with a clause in the original contract, insulated with asbestos. This insulation, however, on account of its hygroscopic qualities, proved itself unsuitable.

Beyond the three modes of measurement already referred to still a fourth method—with which, however, I only became acquainted shortly before the completion of the work—was used. I mean the method described by F. Uppenborn in the *Centralblatt für Electrotechnic* (No. 22, Vol. 1888), in which a torsion galvanometer is used together with a battery having an E.M.F. equal to the E.M.F. to be used in the installation when it is at work.

The lead-covered cables were supplied by Chaudoir (Vienna), and the India-rubber insulated cables and wires by the London Electric Wire Company and Franz Tobisch (Vienna).

Each lead was numbered and lettered in such a manner that it could be recognised. Before taking each set of measurements the test lead itself was tried, and when this was found to be in order the regular tests were commenced. The lengths of the cables as far as they were known, or could be averaged, were noted down, and to what extent and in what manner they were fitted with their lamps. When a three-wire group of the second order had its lamps in position, it gave, as one might expect, the same value of insulation resistance for all three wires, whether positive, negative, or alternative. The order in which the tests were taken was throughout as follows:—First, all distributing cables of the second order (*see* those marked A_2, Fig. 1) were measured. Amongst these were the asbestos-covered cables in the dressing rooms, of which mention will be found elsewhere, and which were replaced by others later on. Of these distributing leads of the second order the greater part was not fitted with lamps at the time, and could therefore be tested singly. A test was also taken of the large lustre in the auditorium. This has separate cables (of the first order), and was fitted at the time with its 373 lamps. The above distributing leads were later on jointed up to the distributing leads of the first order, and these in their turn to the main bars on the switch-boards (*see* A, Fig. 1). Next, the testing of cables in groups was taken in hand, *i.e.*, the measurement of the insulation resistance of the 94 distributing leads of the first order, composed of 3 and 2 wire sets (in all 34 sets), with their branch wires and lamps, and here the loss on the switch-boards had to be taken into account. Finally, I took the insulation resistance of the two complete groups marked A and B in Fig. 1., *i.e.*, the whole system of cables with the exception of those belonging to the stage, then of the stage itself, and then of the whole network connected up together. In addition to these tests fresh measurements were made of those cables which had been repaired or renewed, so that the total number of individual tests was brought up from 600 to nearly 800.

The above tests can be arranged under three heads, which give at the same time the order in which they were taken, *i.e.*, tests of single cables, tests of cables grouped together, and tests of the whole network of cables as coupled up. With regard to the results obtained, I am, of course, unable to publish the notes themselves, containing as they do particulars of over a thousand tests taken during a period of ten months. I must therefore content myself with giving a few of the principal results. With regard to the measurements of single cable, the insulation, with the exception of those damaged by moisture or other means, as mentioned above, was altogether excellent. Out of about 600 cables which were measured singly the greater part had an insulation resistance of several megohms, many had more than 100 megohms, some even a resistance from 400 to 500 megohms and over.

The great lustre in the auditorium, which carries 373 lamps, supplied through about 250 metres of wire, gave an insulation resistance from wire to metal of 1·4 megohm. The chain by which the lustre is suspended is insulated from the lustre itself, the value of this insulation being 61 megohms.

For the hair curling apparatus a special lead was laid, as on account of the current these required (about the equivalent of six lamps of 16 candle-power for each apparatus) it did not seem advisable to put them on the lighting leads already laid.

Of course the measured insulation resistance of a complete system of cables is always less than that obtained by calculation from the measured resistances of the individual wires which make up the system, because all switches, safety fuses, &c., connected with the cables must inevitably cause an additional leakage of current. A further decrease of insulation resistance is found if the lamps are put on to the wires. To find a mean of the single cables I asked my assistant (Mr. G. Frisch) to take at random a number of the results already obtained, and to calculate the average insulation resistance for a given length of cable. For this purpose the 72 cables leading to the boxes of the theatre, which had given average results, were chosen. An average insulation resistance of 1·7 megohm per kilometre was found. Later on we shall see that when we pass from single cables to a network this average is reduced to less than one-tenth in value.

In the groups described above the insulation resistance may be reckoned at ten thousands of ohms, lying, as it does, between 7,000 and 60,000 ohms, so that we have an average of rather more than 40,000 ohms for one of the 34 groups (each consisting of 94 distributing leads of the first order, with branch wires and lamps). This insulation resistance of the four main switch-boards was about 60,000 ohms, and is therefore the outside limit of the insulation resistance of any group connected up.

Whilst testing single wires I noticed an electric current pass through the slate (the fuse being open), when by accident a wire conveying a current made contact temporarily with the slate. It showed clearly on the mirror galvanometer. Similar observations were made at the main switch-boards, even when only one of the main lines connected with them was in use for lighting.

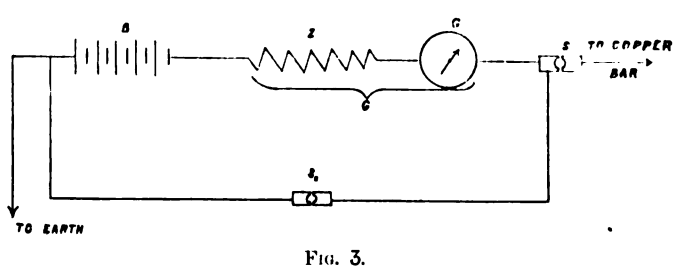

Fig. 3.

The final tests of the whole installation were made as follows:—A small accumulator battery, B (Fig. 3), of 52 cells in series, was used with one of Siemens and Halske's torsion galvanometers, *g*, constructed for strong currents with the necessary resistance box. By means of this extra resistance $Z = 999$ ohms, the total resistance of the galvanometer was made $G = 1{,}000$ ohms, the resistance of the instrument itself being 1 ohm. In this way a deflection of one degree per volt was obtained. The end of the wire, which could be closed or interrupted by means of a plug, S_1, was, the lighting accumulator being disconnected, attached to one of the three copper bars with which the above 94 cables are in connection. The other pole of the measuring battery was put to earth, and between *a* and *b* a shunt was connected which could be closed or interrupted by means of the plug S_2.

The Uppenborn method was employed as follows:—First, S_1 was left open and S_2 closed. Then, neglecting the resistance of con-

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necting wires, the potential Δ of the measuring battery gives a throw on the magnet, which is then balanced by torsion of the angle ϕ, as shown in the equation

$$\frac{\Delta}{G} = k\phi.$$

If S_2 be opened and S_1 closed, the insulation resistance to be measured is joined up in circuit, and a deflection ϕ^1 is obtained, as shown in the equation

$$\frac{\Delta}{G+x} = k\phi^1,$$

k being in both equations a constant of the instrument.

From the above we have

$$x = G\left(\frac{\phi}{\phi^1} - 1\right),$$

and in this case G = 1,000.

First, the insulation resistance of all the cables was taken with the exception of those in use for the stage. These I shall call the stage circuits in distinction to the other, or house circuits. The house circuits start from three copper bars, to which the three mains from the accumulator batteries I. and II. are connected. It was therefore necessary to interrupt the connection between these mains and the copper bars.

The measuring lead from the torsion galvanometer (*see* Fig. 3) was then connected to one of the three copper bars. The results of the tests were as follows :—

1st test ... $\phi = 109{\cdot}3$; $\phi^1 = 49{\cdot}0$; therefore, $x = 1{,}230$ ohms.
2nd test... $\phi = 108{\cdot}3$; $\phi^1 = 48{\cdot}1$; therefore, $x = 1{,}250$ ohms.

From this we have an average of 1,240 ohms for the total insulation resistance of the house circuits. The length of cable is 100 kilometres. The test of the stage circuits, which are fed by two main cables marked B, leading from the accumulator battery III., was taken in the same manner, and the following results obtained :—

1st test ... $\phi = 108{\cdot}3$; $\phi^1 = 30{\cdot}9$; therefore, $x = 2{,}500$ ohms.
2nd test... $\phi = 109{\cdot}2$; $\phi^1 = 31{\cdot}9$; therefore, $x = 2{,}420$ ohms.

Taking the mean of these we have an insulation resistance of 2,460 ohms for the stage circuits. The length of cable is 10 kilometres. I then coupled up both circuits together, with the following results :—

1st test ... $\phi = 109{\cdot}2$; $\phi^1 = 59{\cdot}2$; therefore, $x = 840$ ohms.
2nd test... $\phi = 108{\cdot}0$; $\phi^1 = 59{\cdot}0$; therefore, $x = 830$ ohms.

So the mean insulation resistance of the whole network, containing 110 kilometres of wiring, is 835 ohms. Taking the insulation resistance of the house circuits as connected in parallel with that of the stage circuits, we have by calculation

$$\frac{1{,}240 \times 2{,}460}{1{,}240 + 2{,}460} = 823,$$

which agrees well enough with that found by measurement. We will compare these results with a formula proposed by Mr. F. Ross for the insulation resistance test of electric light installations, namely :—

$$W = 10{,}000\ \frac{E}{J}$$

where W is the insulation resistance of the whole network, E the difference of potential used, and J the total current employed for lighting.

As previously stated, out of the total number of 5,300 lamps 1,970 serve to light the stage, the greater number of these requiring a one-ampere current. We have, then, for the stage circuits (system B) J = 2,000 nearly, and as the difference of potential may be taken as E = 100, there should be, according to Ross's formula, an insulation resistance of

$$10{,}000\ \frac{100}{2{,}000} = 500 \text{ ohms.}$$

The tests gave a result nearly five times as large, viz., 2,460 ohms.

The house circuits (system A) have about 3,300 lamps. Reckoning these as requiring on the average currents of 0·5 ampere, and adding 100 amperes for ten arc lamps, at 10 amperes a piece (which belong to the house circuits), we have J = 1,750 amperes. The difference of potential is twice that in use on the stage, *i.e.*, E = 200, and we find from the Ross formula the value of the insulation resistance as

$$10{,}000\ \frac{200}{1{,}750} = 1{,}143 \text{ ohms.}$$

The actual measurement, however, gave the far higher result of 1,240 ohms. In comparison with the actual current used, the figures given above are too high, as all the lamps are never burning at the same time. But, in my opinion, not only the number of lamps burning but all those put up should be included under the J of the Ross formula, as it professes to be a test of the whole wiring.

The result for the total network ought to have been (according to the values reckoned above, namely for A and B 1,143 and 500),

$$\frac{1{,}143 \times 500}{1{,}143 + 500} = 348 \text{ ohms,}$$

whereas the actual test gave 835 ohms.

In the book by Killingworth Hedges, on the "Precautions to be Adopted on Introducing the Electric Light," p. 41, we find the rule given that a network of wires should have an insulation resistance of at least 500 ohms per volt difference of potential employed. This would be the more difficult to obtain the greater the extent of the installation, and with a very large installation would be impossible.

The tests would appear far better if judged, not by the Ross formula, but by that of the Electro-Technical Society, in which the coefficient 5,000 is used instead of 10,000. The results of the final tests would then satisfy the strictest requirements.

As far as I am aware, this is the most comprehensive and exact examination of this kind yet made, or at least published.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, February 15th.

SOCIETY OF ARTS.

8 p.m. Indian Section, "The Ruby Mines of Burmah." By G. SKELTON STREETER, F.R.G.S.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Electrical Stress." By Prof. A. W. RÜCKER, M.A., F.R.S.

SATURDAY, February 16th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Character of the Great Composers and the Characteristics of their Works." By Prof. ERNST PAUER.

SATURDAY LECTURE SOCIETY.

8 p.m. Lecture in the Lecture Theatre of the South Kensington Museum, "Hypothesis of the Meteoric Origin of the Heavenly Bodies and the Earth" By Prof. J. NORMAN LOCKYER, F.R.S.

MONDAY, February 18th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture III. 2.—"Wood Engraving." By W. J. LINTON.

TUESDAY, February 19th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "Alternate-Current Machinery." By GISBERT KAPP, A.M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. "Slavery in Relation to Trade in Tropical Africa." By Commander V. LOVETT CAMERON, C.B., R.N.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture, "A Chapter in Darwinism. By Dr. W. D HALLIBURTON.

WEDNESDAY, February 20th

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read, "Report on the Helm Wind Enquiry, by W. MARRIOTT, F.R.Met.Soc.; "An Atmospheric Sketch," by F. A. VELSCHOW, F.R.Met.Soc.; "The Drought in New South Wales in 1883-4, and Rainfall at Corella, 1879-88," by the Ven. Archdeacon WYNNE, F.R.Met.Soc.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Forth Bridge." By BENJAMIN BAKER, M.I.C.E.

THURSDAY, February 21st.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Venom of Serpents and Allied Poisons." By SIDNEY MARTIN, M.D., B.Sc.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Paper not decided on.

FRIDAY, February 22nd.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Furnaces." By T. A. GUYATT, Stud.Inst.C.E.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert at the St. James's Hall Restaurant. Ladies' Night.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "In the Heart of the Atlas." By HAROLD CRICHTON-BROWNE, F.R.G.S.

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The Electrician.

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CONTENTS OF THE CURRENT NUMBER.

NOTES	421	The Mœnnich Indicator. Illus.	438
The Electrolytic Separation and Refining of Metals. By Dr. G. Gore, F.R.S.	426	The Aron Meter: Latest Type. Illustrated	438
Reviews	427	American Notes	439
Report on the Insulation Measurements made on the Electric Lighting Installation in the New Court Theatre, Vienna. By Dr. A. Von Waltenhofen. Illustrated	428	CORRESPONDENCE—	
Meetings of Scientific Societies.	431	The Effect of Currents upon Conductors.—A. T. Bartlett	440
LITIGATION AND ARBITRATION	432	The Regulation of Dynamos by Means of a Third Brush. Edward L. Nichols. Illus.	440
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued	433	Lightning Conductors.—W. G. Forster	441
The Siemens Arc Lamp. Illus.	435	Globular Lightning.—Sydney Evershed	443
Sprague Motor Truck for Street Cars. Illustrated	435	Constant Current Regulation. John Smith and Co.	443
Ryde Pier Electric Railway	436	PATENT RECORD	443
Electric Meters for Central Stations.—*Discussion.* Illustrated. Concluded	436	COMPANIES' MEETINGS, &c.—	
		The India-Rubber, Gutta-Percha and Telegraph Works Company (Limited)	444
		New Companies Registered	445
		City Notes, &c.	445
		Companies' Share List	446

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LITIGATION AND ARBITRATION.

Not the least of the many advantages which Chambers of Commerce have conferred on the mercantile communities of this country is the system of arbitration provided for disputants who would otherwise resort to the Courts of Law. Trade disputes are peculiarly susceptible of treatment by arbitration, the parties being for the most part actuated by no personal feeling, and having no litigious motives such as commonly give rise to actions at law. Generally the point in dispute is one of assessment of damages, apportionment of charges, or definition of rights; and when business men differ in their relations on such matters as these their last desire is to appeal to the law, which not improbably will swallow up as much money as the item in dispute is worth. Of late years therefore, and chiefly owing to the exertions of these Chambers of Commerce, arbitration has rapidly grown in favour, and has even found a place in the Law Courts themselves, Official Referees, as they are called, being now the recognised instruments for dealing with matters either too intricate or too

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technical for the ordinary Judges to deal with, or so free from legal difficulty that the Court's time need not be wasted upon them. It is now quite common for Judges to refer to arbitration cases which involve no point of law, and the practice it may be hoped will be still further extended. But for many of these actions the Chambers of Commerce have long been open, and the simplicity and inexpensiveness of their procedure, together with the special fitness of their arbitrators, afford an attractive and unexceptional substitute for any lawsuit to which the parties might otherwise be compelled to appeal.

It will be of interest to the electrical trades to learn that the London Chamber of Commerce possesses a permanent Arbitration Committee, whose object is to facilitate the settlement by arbitration of "disputes arising out of commercial transactions," and whose duty it is to consider, first, whether the case brought before them is suitable for such reference, and then, if desirable, to name one or more arbitrators specially qualified to deal with it. The selection is made from the Section representing the trade to which the dispute pertains; but the assent of the disputants to the nomination is, of course, obtained as a preliminary; and when this has been settled the arbitrators proceed with the investigation. It would seem, though the wording of the bye-law is not quite clear on this point, that one of the disputants may even proceed without the consent of the other, and the arbitrators decide the case *ex parte*. This will perhaps rarely occur; but we can easily see the advantage of submitting to arbitration, even if nothing comes of it, should the case be carried by the dissenting party to a Court of Law. He has, however, another remedy by way of appeal to the Chambers' Permanent Committee, the fee for which is heavier, but the decision of which is final, no case being referred to that Committee unless both parties agree to be bound by its ruling.

By throwing in their lot with the London Chamber of Commerce the electrical trades have secured for themselves and allied industries—for the system is not confined exclusively to members—the advantages of this admirable method of settling their differences. Many of these will fall naturally under the head of "disputes arising out of commercial transactions;" but some others which are of a more technical character may very well come to be regarded as covered by that definition. Of these latter many at least of the actions relating to electrical patents which are continually occupying the attention of the Law Courts might certainly be so treated, at all events in their initial if not in their final stages. Litigation in the majority of these cases would have been averted had the parties been able to appeal with confidence to such a body of men as are now available as arbitrators attached to the London Chamber of Commerce, and we suspect that the final decisions in every case would have been quite as satisfactory to everybody concerned as are those now being delivered in the Courts of Appeal. In the matter of costs they would have been infinitely more satisfactory; and as regards technical and practical knowledge hardly less convincing. It has often been argued that the Patent Office, which grants the patent, should determine its validity when challenged. If ever that argument is acted upon, a jury of experts will be the kind of authority called into play; and, meanwhile, this is precisely the jury we possess, though without legal status, in the Trade Sections and Arbitration Committee of the Chamber of Commerce. The requisite binding force of its decisions is obtained by a formal undertaking entered into by the disputants, effectually preventing any subsequent legal proceedings on the specific matter in dispute. It is here that arbitration has such vast superiority over the law, the uncertainty of whose decisions and the unlimited openings it affords for further proceedings being a continual temptation to persevere in a course of litigation which would be ruinous if stopped, and can only mean ruin if it fail.

That this is a tolerably fair description of some of the patent cases which for years have been encumbering the Law Courts nobody who carefully follows our reports can fail to have seen. Nor can it be doubted that, generally speaking, the merits of the essential points in dispute would be more equitably adjudicated upon by independent experts than by legal adepts, whose object it is to win a case whatever its merits or demerits may be. Of the Judges we cannot speak too highly, the labour they bestow in discharging a thankless and alien task being as surprising as it is praiseworthy. But they have to rely upon the Bar to "inform" the Court, and not in every case are members of the Bar competent, even if they are willing, to perform this necessary duty. It sometimes happens, as in a quite recent suit, that the judges have to complain that they are *over much* informed, the statements and arguments being spun out to such inordinate length that the gist of the matter is buried under mountains of rhetoric. In the case referred to Lord Justice LINDLEY, one of the Appeal Judges in *re* Gaulard and Gibbs's Patent, declared that ten days had been occupied with what need only have taken up four. His lordship would have been nearer the mark, regarding the case from our point of view, if he had said as many hours as it had occupied days. For we suppose nobody will deny that, not in this case particularly, but in all similar cases brought before the legal tribunals, the technical features are manipulated in such a way as to puzzle even the most conscientious of laymen, and are so mixed up with legal subtilties as to mislead even the most learned of lawyers. The evil grows apace as these cases become more numerous, and if not speedily abated will inflict irreparable injury upon every industry that depends on the integrity of patent rights. To electrical industry especially it has done grave mischief already; and on this account we look with hope to the alliance of electrical trades with the London Chamber of Commerce as a means of settling these disputes in the first instance, and preventing them being handed over to the legal profession whose interest it is to unsettle them.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION III.—MAGNETIC FIELDS OF COILS AND SOLENOIDS.

(Continued from page 403.)

145. *Intensity of Field in the Region of a Circular Current. The C.-G.-S. Unit of Current.*—In the preceding paragraph we investigated the direction of field along the axis of a ring conductor carrying a current, and that direction we considered in one plane only of the ring. What is true for one plane is true for all sectional planes of the ring, and a little consideration will show that the *entire* magnetic field (or force on unit pole) set up at a point on the axis, that is, the field due to the current in the ring conductor, *as a whole*, will be acting at the point round a cone-like surface. This effect of the entire field at the point may be understood by the perspective view of the ring and the forces set up by it at the point p in Fig. 133. Here A B is the axis of the ring as before, and if we imagine a unit north pole at the point p, it would be urged outwards from the ring along the axis towards B. In this direction there must evidently be one resultant force equal to the combined forces acting round the cone at the point, and it is this resultant that we have to find. Now, any point on the axis A B is equidistant from every portion of the ring conductor; and when this is the case the *total* intensity of

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field at the point is directly proportional, by Ampère's law, to the length of conductor multiplied by the strength of current, and inversely proportional to the square of the distance between the point and conductor. The distance between any point on the axis and the conductor is simply the common radius to all those circles of force which pass through the point. If we take R as this radius, C as the current, and L as the length of conductor composing the ring, the total intensity of field at the point is proportional to

$$\frac{C\,L}{R^2}.$$

Now, to find the resultant of this field along the axis, let us consider one plane through the cone, as before. Here

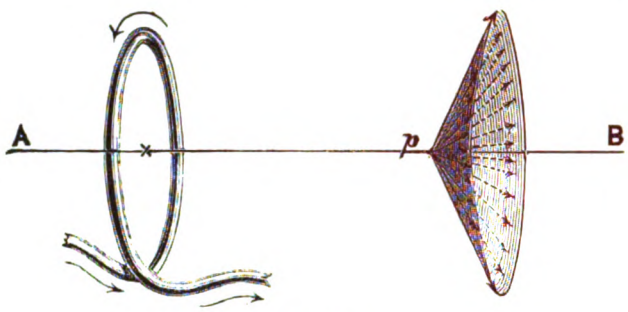

Fig. 133.

we have two diametrically opposite forces, each, say, equal to F (Fig. 134), acting at the point p, as tangents to the circles of force through the point, or in other words, at right angles to the common radius R, of the circles of force through p. Completing the parallelogram of these forces, and calling f the resultant of the pair, we find by similar triangles that

$$f : F :: 2r : R,$$

where r is the radius of the ring conductor whose opposite sectional portions are at W W, that is,

$$f = F\frac{2r}{R}$$

Now it is evident that the resultant of the whole cone of forces bears the same relation to the combined intensity of

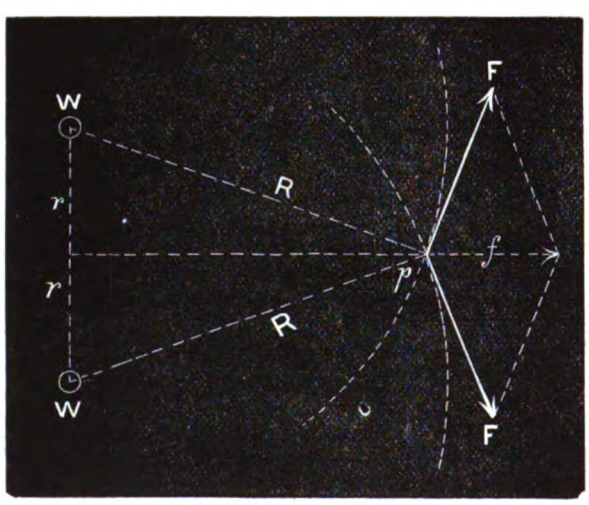

Fig. 134.

those forces as the resultant (f) of the pair (2 F) bears to that pair. Therefore we have the relation,

$$\frac{\text{Resultant field}}{\text{Total field}} = \frac{f}{2F}.$$

Substituting the value of f as obtained above, and cancelling, we have

$$\text{Resultant} = \text{total field} \times \frac{r}{R},$$

$$= \frac{C\,L}{R^2} \times \frac{r}{R}.$$

Now, the length of conductor (L) in a ring of radius r is equal to $2\pi r$, and therefore we have,

$$\text{Resultant along axis} = \frac{C\,2\pi r}{R^2} \times \frac{r}{R},$$

$$= \frac{2\pi C r^2}{R^3}.$$

This is a very important expression, as it is proportional to the field at any point along the axis of a coil. We have not yet taken the quantities in any fixed system of units, so that the expression as it stands must be regarded as simply proportional to the field.

Now in this expression we notice that the numerator is constant for a given current flowing in a ring of given size, and the field at any point along the axis of the ring is inversely proportional to the cube of the radius of the circles of force through that point, that is, the cube of the distance of the point from the conductor.

It is interesting to represent graphically the rate at which this field decreases as we take points further and further from the coil. All that is necessary is to take measured distances along the axis A B of the coil (Fig. 135), starting from 0 at the centre of the coil, and for each of these distances calculate the radius R, then cube it and take its reciprocal, the resulting number being proportional to the strength of field at the points taken. For instance, taking the radius of the ring as unity, and the strength of field at its centre as 1,000, we find

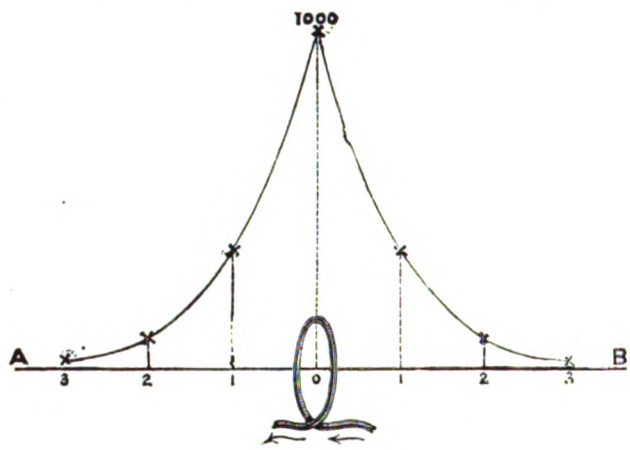

Fig. 135

that at the distances one, two, and three the field is proportional to 350, 89, and 32 respectively. It will be noticed in Fig. 133 that R forms the hypothenuse of a right-angled triangle, of which one side is the radius (r) of the ring, and the other is the distance (d) of the point on the axis from the centre of the ring. We have, therefore, the relation (Euc. I., 47)

$$R^2 = r^2 + d^2$$

whence

$$R^3 = (r^2 + d^2)^{\frac{3}{2}},$$

from which the cube of the radius R may be found for any distance from the centre of the ring. Raising vertical ordinates proportional in height to the field at the several points chosen, and connecting them, we obtain the curve in Fig. 135, showing the rate of decrease of field on each side of the ring along its axis.

It will be seen that at the centre of the ring R is equal to r, and therefore the field is proportional to

$$\frac{2\pi C}{r}.$$

Now, in the relation of these quantities there are two, viz., intensity of magnetic field and length, which have already been defined, and units fixed on the absolute C.-G.-S. system. There is one quantity, viz., the current, of which we have not yet exactly defined an absolute unit. If we make C and r equal to unity in the above relation, the strength of field at the centre of the coil becomes numerically equal to 2π, and expressing the strength of field in C.-G.-S. units, we can define the unit of current on the C.-G.-S. system as that current which, flowing in

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a circular conductor of one centimetre radius, produces at the centre of the coil a magnetic field equal to 2π C.-G.-S. units. The practical unit of current, to which is assigned the name of Ampère, is chosen as equal in value to *one-tenth* of the absolute unit, and therefore one ampere flowing in a ring conductor of one centimetre radius produces a field of

$$\frac{2\pi}{10}, \text{ or } \frac{\pi}{5} \text{ C.-G.-S. units.}$$

If the ring or coil consists of more turns than one, say n turns, the field is increased n times, and the complete expression for the field at any point becomes

$$\frac{2\pi C n r^2}{R^3} \text{ C.-G.-S. units,}$$

where r is then the *mean* radius of the coil in centimetres.

Example.—The coil in Sir Wm. Thomson's graded current galvanometer (described para 132) consists of six complete turns of stout copper strip, the inside diameter being 6 centimetres and the outside 10 centimetres. What is the intensity of field produced by a current of 30 amperes flowing through the coil, at a distance of 10 centimetres from the centre of the coil along its axis, and what is the field produced at the centre of the coil?

Mean radius of coil (r) $= 4$
Current in C.-G.-S. units (C) $= 3$
Number of turns (n) $= 6$
$2\pi C n r^2 = 1809{\cdot}5$
log of $1809{\cdot}5 = 3{\cdot}25755$

$R^3 = (r^2 + d^2)^{\frac{3}{2}} = (16 + 100)^{\frac{3}{2}}$
log of $116 = 2{\cdot}06445$
log of $R^3 = \frac{2{\cdot}06445 \times 3}{2} = 3{\cdot}09667$

Subtraction gives log of answer $= {\cdot}16088$

Therefore,

Intensity of field $= 1{\cdot}448$ C.-G.-S. units.

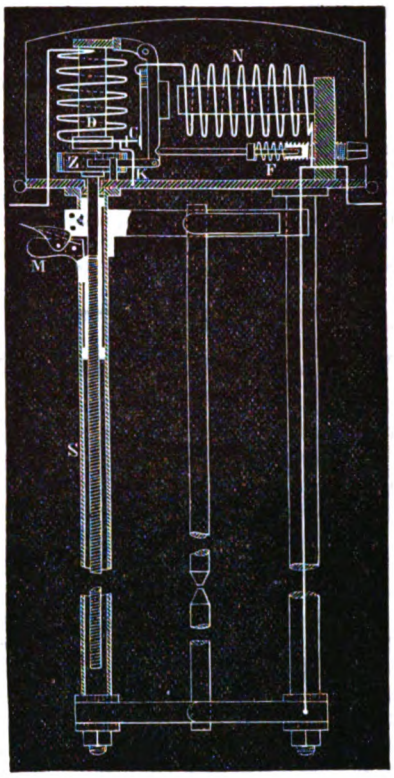
Field at coil centre $= \frac{2\pi C n}{r}$ C.-G.-S. units.

$= \frac{56{\cdot}55}{4} = 14{\cdot}14$ C.-G.-S. units.

(To be continued.)

THE SIEMENS ARC LAMP.*

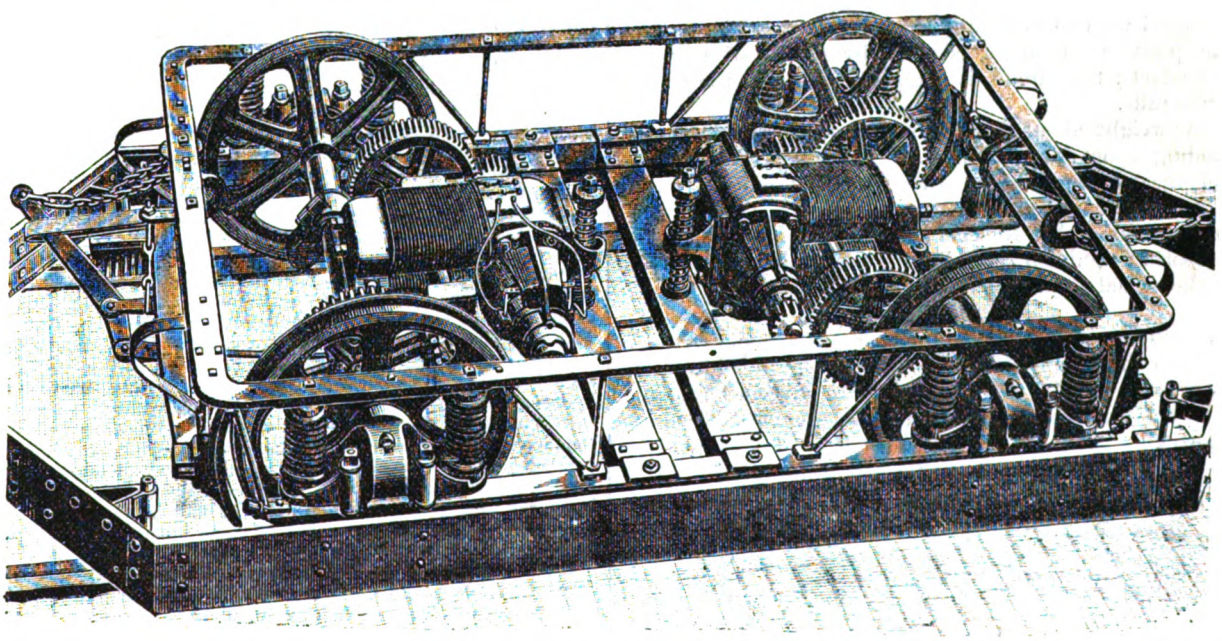
The accompanying figure represents the latest (1886) type of the well-known arc lamp manufactured by the firm of Siemens and Halske. There are two electro-magnets, D and N, wound with thick and thin wire respectively, D being used to strike the arc, and N



to regulate its length. The electro-magnet N is provided with a trembler, C, which actuates the toothed wheel Z, and in this way turns the screw S, contained in one of the rods of the lamp. The

* Translated from M. Hippolyte Fontaine's "Eclairage à l'Électricité," by permission of the author.

SPRAGUE MOTOR TRUCK FOR STREET CARS.



The adjoining engraving shows the latest design of Mr. J. T. Sprague for tramcar trucks. Each motor is of 15 horse-power, and is geared to the axles through an intermediate shaft, which passes between the field-magnets. The small pinion on the armature shaft has teeth of vulcanised fibre. The motor is swung from the axle on one side, and flexibly supported on the other. Everything is designed to reduce the care and attendance to a minimum; all bearings are self-oiling and dustproof, and each is removable.

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upper carbon-holder slides between the two vertical rods, and by means of the little mechanism at M, it can be made to engage with the screw S, so as to descend as the screw turns. When the current traverses the lamp, the wheel Z, which acts as armature to the electro-magnet D, is attracted, and lifts the positive carbon. The wheel Z is made thick enough to prevent the detent K quitting it when Z is attracted by the magnet. If the arc becomes too large, the electro-magnet N attracts its armature and actuates the trembler C, which is simply a little electric motor similar to that employed in the original Siemens lamp; but with this difference: in the original lamp the carbons were pulled apart when they approached one another too closely under the action of gravity, while in the present type of lamp the carbons are made to approach as soon as the arc becomes too long. A screw on the outside of the lamp permits of the spring F being regulated as desired. When recarboning the lamp, M is unbraked, allowing the upper carbon holders to move freely.

This lamp is a happy combination of the old pattern Siemens and the Cance lamp. The mechanism is compact and simple, and all the essential parts are well constructed. The carbon clips, however, seem somewhat too large to allow of very accurate allignment of the carbons.

RYDE PIER ELECTRIC RAILWAY.

Although the electric railway on Ryde Pier cannot be described as an engineering enterprise either of great magnitude or of profound difficulty, yet, as one of the earliest electric tram lines in this country, and one which both technically and commercially has given entire satisfaction from the very first, a brief description of the arrangements adopted will be of interest.

The line is on the level throughout, without curves, and is 716 yards long, the gauge is 4ft. 8½in., and there are two sidings. The generating plant consists of a 12 horse-power Otto gas engine, driving a Siemens S B_8 dynamo, at a speed of about 1,000 revolutions per minute, when it gives a current of 60 amperes with an E.M.F. of 120 volts. The current is conveyed from the engine-house by underground cables to the tram line. As the line on the pier is entirely fenced off from the public promenade, a bare channel-iron by the side of the line is used as a positive conductor, the tram-rails serving as a negative conductor. The channel-iron is carried on insulators attached to cast-iron brackets, which are bolted to the sleepers. The total resistance of the line is 0·275 ohm.

The motors are of the Siemens horizontal type, D_2, fixed under the cars. The transmission is effected by means of a pitch-chain. Each D_2 motor is sufficiently powerful to propel its own car and a second one attached thereto. The motors are each fitted with starting and reversing gear. The contact with the positive conductor is made by means of a spring rubbing contact; the circuit is completed through the wheels to the tram-rails.

Each car weighs about 5 tons; it has seats for 18 persons, and standing room for 12 more. The cars are lighted by means of incandescent lamps, the necessary current being derived from the main conduits.

By the courtesy of Mr. Roberts (the Secretary and Manager) we are enabled to publish the following comparative statement, showing the actual results of working by horses and by electricity.

It is as well to note that the number of passengers carried is obtained from the number of tickets issued, but in addition to these all persons holding railway tickets to or from Ryde, and all persons holding passes and free tickets, are entitled to use the tram-cars.

Half-Year ended 31st December, 1885.

TRAM-LINE WORKED BY HORSES.

Hire of horses and drivers	£ 34 0 0	
Conductors' wages	31 4 0	
Repairs and incidental expenses	10 0 0	
Oil for lighting cars	1 10 0	
		£176 14 0
Cash Receipts	£350 18 7	
Passengers carried	72,802	
Train miles	5,258	

Receipts per train-mile, 15·9d. Expenses per train-mile, 8·02d.

Half-Year ended 31st December, 1886.

TRAM-LINE WORKED by ELECTRICITY.

Gas consumed in engine— 289,200 feet (cubic) at 3s. 11d. per 1,000, less 5 per cent.	£53 16 0	
Wages of conductor and boy	39 16 0	
Wages of engine driver and assistant	64 6 6	
Repairs and incidental expenses	15 18 7	
		£173 17 1
Cash Receipts	£532 2 1	
Passengers carried	113,733	
Train miles	6,435	

Receipts per train-mile, 19·9d. Expenses per train-mile, 6·48d.

ELECTRIC METERS FOR CENTRAL STATIONS.*

(Concluded from page 396.)

DISCUSSION.

The CHAIRMAN called upon Mr. Swan to open the discussion, but that gentleman having to catch a train, promised to send a written communication to the Society on the subject of the Paper.

Mr. CROMPTON was then called upon. He regretted that Mr. Miller was not present to speak, as it was owing to that gentleman that the meter they used (the Aron meter) had been so successful, many of the alterations which had been made in it being due to his perseverance. They had not always used the Aron meter; but had commenced with another which was not so satisfactory. The latter was superseded by an Aron meter in its original form, with a clock which was started when the current was turned on. Its heat, however, gave endless trouble. Suggestions were made, which resulted in the invention of a single clock which they were now employing, and which he believed ran up to 30 days. The many difficulties attending Aron's meter had now been removed. He had recently spent some considerable time in Berlin, where he had had opportunities for carefully inspecting the whole of the system. He believed they were now perfectly satisfied with the meter, but he thought that only the current used by incandescent lamps was registered. The success of the Berlin system entirely depended on the arc lamps, as there were very few incandescent lamps in that city. There was a company at Liverpool which was also working largely by meter. They had introduced one made by Chamberlain and Hookham, which he believed was as accurate as Aron's meter, and in some points was superior to it. He agreed with Prof. Forbes about the Edison meter; there was infinitely more real work done by it than by any other meter in use, and its accuracy was astonishing. At the time Mr. Ferranti brought out his meter, Mr. Kapp and himself were experimenting on a meter very much like Ferranti's, which they carried up to the point Ferranti did, but Mr. Ferranti was just a few days before them. Certainly Mr. Kapp did invent a meter which was in every way almost identical with Mr. Ferranti's. In considering the question of candle-power they must remember that English people lived more at home than the Germans or the Americans. We have consequently heavy bills to pay for lighting the hall, passage ways, &c. For our purposes, therefore, a unit of eight candles answered extremely well. No one who saw such a light objected to its being very small, and there was no one who had seen the sixteen-candle lamps sent out by the Edison and Swan but admitted that they were too big for this purpose. His customers bought a small lamp; more than three-fourths of his lamps and those of his customers were small. He believed the experience at the Grosvenor Gallery was very much similar. In shops, clubs, and hotels no doubt the larger light was more satisfactory. If they wished to make the electric light spread and did not wish to frighten people by the cost of the electricity, they ought rather to encourage the use of small lamps (applause). The Leipziger Strasse Station at Berlin was a triumph of spending money; there was no doubt that in England the same thing could be done with equal efficiency for less money (hear, hear).

Prof. AYRTON said they had listened to a most interesting Paper, delivered in a most interesting way. Considering that the author was the inventor of an extremely pretty meter, they must admire the modesty with which he had described his own meter. He would like to break a lance with the author with reference to his remarks as to whether they should charge by quantity or by energy. People were somewhat influenced by the meters they had to supply, and they naturally liked that people should pay for a thing which their meter would measure rather than that the meter should measure the thing they ought to pay for (laughter). No doubt if it were possible to maintain a perfectly constant potential difference between the supply mains, the total quantity of electricity supplied in a given time was all that they need consider or pay for. But let them take things as they were. Is that constant difference of potential maintained? Prof. Forbes even admitted a four or five per cent. variation.

Prof. FORBES: A total variation up and down of two or three.

Prof. AYRTON said he would take it at 2½ per cent. variation. True that only meant 2½ per cent. variation but it meant more than that in the watts, as the resistance of the filament diminished as the volts increased—and think what it meant in the light. The light was what they bought. Speaking as a private person, knowing nothing whatever

* A Paper read before the Society of Arts on Jan. 23, 1889, by Prof. G. Forbes, F.R.S. (See *Electrician*, Feb. 1 and 8.)

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about electricity (laughter), but having incandescent lamps in his house, he did not care anything about watts or volts or amperes, or any technical units; but what he did care about was this—he bought light, and he wanted his meter to measure more or less approximately what he was paying for. A drop of 2½ per cent. in the volts (it was a great deal more in practice) meant a very considerable drop in the light. The light given out by an incandescent lamp was about proportioned to the cube of the volts minus a constant, as Prof. Perry and he had shown some years ago, so that a variation of three or four volts in a hundred meant a very considerable variation in the light. Nobody admired more than he did the success that the Grosvenor Gallery Company had attained, and the enterprise they had shown in getting over all kinds of difficulties; but at the moment he had nothing to do with that—he was a buyer of light. He was recently at the St. James's Hall, at one of the Saturday afternoon concerts, when during the performance the lights went down so much that the gas had to be all turned up. Supposing they were paying simply by current, they would pay perhaps not very much less than if the right voltage was maintained between the terminals. Supposing that they turned on a few more lamps, so that the total current was the same as it would have been if the right voltage had been maintained, then the bill would be identically the same; but the light obtained was nothing like the same. The light obtained was so little that they had to turn on the full amount of gas, and during that half-hour or so they were actually paying the full gas bill and probably the full electric light bill. Nothing more was needed to show that what the meter ought to measure was what they paid for, and not what they would like to have to pay for. He would go even farther in the opposite direction, and say "Not merely will I measure watts, but I should like the instrument to measure a higher power than the first of the volts into the current." There is one point about simplicity of testing which Prof. Forbes, having so much to say, did not refer to, and which exists with retarded clock meters, but does not exist, he thought, with any other meters. During the time that they were not using electricity they could check the accuracy of the retarded clock meter, because, if they had a simple clock which was retarded when the current was supplied, of course it ought not to be retarded when no current was supplied. All they had to do, therefore, was to compare the going of the ergmeter with the going of a respectable watch; and that in itself formed a very efficient check on the accuracy of the instrument. Any other of these meters (which might be called for simplicity motor meters) could not be tested in that way, because they only worked when the current was started. There was also one way, which his colleague and himself proposed some years ago, of getting over the possibility of cheating. He referred to their ergmeter, which measured the product of current into volts. By putting a magnet near the clock the consumer could no doubt prevent it being retarded so much; and what they proposed to do was occasionally to reverse the current in the whole system, which by a simple arrangement could be accomplished. The result of that would be that anybody who tried to cheat by putting a magnet near would be just as likely to raise his monthly bill as to lower it (laughter and applause). He agreed with Prof. Forbes's remarks as to the objections to contacts in meters. There was one form of meter (also an ergmeter—a motor ergmeter), which Prof. Perry and he had patented some seven years ago, which had a contact—had two contacts, in fact—but he did not think it was open to objection, at least not to the same extent, on that account. It was a motor, the field-magnets of which were wound with thick wire, and there was a continuous circuit through them—no make or break at all. The rotating armature was wound with very fine wire of very high resistance, and there were two brushes to lead the shunt-current through the armature. Any slight change in the resistance of those brushes made but very little difference in the total resistance of the shunt circuit. There were no brushes in the direct circuit, and therefore a little change in the resistance made no change in the accuracy of the instrument. Dirt accumulating year by year under the brushes introduced very little error. With reference to the question of fluid friction, Prof. Forbes had spoken of the force being proportional to the square of the velocity; but surely there must be some mistake in that. With small velocities the retarding force was not proportional to the square, but to the first power of the velocity—a velocity such as existed in Prof. Forbes's very beautiful instrument when the vanes were moving. Those vanes were not moving much faster than the needle of a ballistic galvanometer. The whole calculation of the damping in the ballistic galvanometer depended upon the assumption that the retardation was proportional to the first power of the velocity. He did not, therefore, follow Prof. Forbes's reasoning as to the square of the velocity, and did not agree with the conclusions he had drawn, starting with the wrong hypothesis. While on this subject of fluid friction he was led necessarily to refer to what appeared to him to be the defect of all motor meters. It was this very defect which had prevented his colleague and himself from improving and putting forward prominently (beyond mere publication) their motor ergmeter. They wanted simply to have fluid friction, they did not want solid friction—they must not have the friction of the mechanism. Therefore one was obliged to reduce the dials, the recording mechanism, to very minute dimensions. He understood from Mr. Ferranti that that had been the great difficulty with his meter; if he had no recording mechanism whatever then his meter would be perfect, but it was the friction introduced by the dial mechanism which had made the enormous difficulty in his making his meter successful. The clock-meter had no such defect. There the mechanism was not driven by the current. It was a defect in one sense that they had to introduce another motive force; but introducing that other motive force, namely, a weight or tension of a spring, entirely got over the difficulty. The friction of the mechanism was made up for by the force of the spring, and the solid friction then introduced no more inaccuracy than the friction of ordinary wheel work introduced in a good chronometer. Let them look at the dial in Aron's meter, and compare its large size, its clearness, with the necessary smallness of the dial either in the Ferranti meter or in the very beautiful meter of Prof. Forbes. His colleague and himself owed a debt of gratitude to Dr. Aron for the way in which he had carried out their principle and pushed it so thoroughly in different parts of the world, and as Dr. Aron's agent had wisely recognised commercially their claims to priority of invention, there was perfect accord between them.

He was a little surprised at the success of the Lowrie-Hall meter, because it was based on the assumption that an alternating current when passing through a voltameter or electrolytic cell produced no decomposition. That experiments had shown to be an extremely difficult condition to arrive at. One would think at first sight that if an alternating current were sent through a voltameter there would be no gas whatever produced, but so far from that, one could get a considerable amount of gas produced with an alternating current. For instance, copper could be deposited with an alternating current making many thousand alternations per minute. That seemed a difficulty, but he was delighted to hear that that difficulty had been successfully overcome. A meter for direct or alternate currents on the same principle as that modestly described by Prof. Forbes at the end of his Paper was made at the beginning of last year by Mrs. Ayrton. In that meter water was evaporated by the passage of the current, the water then fell through the tube, and, according to Mrs. Ayrton's design, worked a recording mechanism, and was finally carried back to the reservoir to be re-evaporated.

Mr. SHOOLBRED said the nominal output of an installation ought not to be measured by the number of lamps, because they found that more and more persons were asking for 30 and 100 candle lamps, and even higher—not to speak of various other uses of a current. It was much better to speak of the relative value of an installation in watts or in amperes. It must be remembered, too, that meters were likely to be placed in cellars.

Mr. SMART said the cost of a meter was an important question for tradesmen.

Prof. FORBES, in reply, said he was quite unaware of the Chamberlain and Hookham meter; he had seen their names in a patent, but he had not been aware that the meter was doing sound good commercial work. The costliness of the station at Berlin was hardly within the scope of his Paper, but he hoped to have an opportunity of saying a word about it elsewhere. Prof. Ayrton said that those who make meters do not make them to satisfy the wants of the customers, but tried to make the wants of the customer satisfy the performance of the meter. Prof. Ayrton's meter measured ergs, and he said: "There is no doubt about it, the ergs are the proper things for you to measure," though he admitted that ergs were not a true measure of the light. Now, he (Prof. Forbes) said the coulombs were the things to measure the total quantity of current passed through. Prof. Ayrton said: "Not so; when my lamps are burning down very low it is a great shame that I should be charged almost as much as when they are burning quite bright." Assume that he (Prof. Forbes) wanted to have lights supplied to his house by meter, and that the people were going to charge him by ergs, those people would of course be always wanting to put on a greater pressure than he wanted, and they would be continually breaking his lamps. Not only would he be injured by having his lamps broken, but he would be insulted by being asked to pay more in his meter account (laughter and hear, hear.) He thanked Prof. Ayrton for his reference to another inventor who had been working on the lines of evaporation. A great number had been trying it, but he had not seen another one yet which had made the results proportional to the current going through the meter, and he was sorry that Prof. Ayrton had not explained whether that was done. In reply to Mr. Smart, he had very little knowledge about the cost of the different meters. In America the general idea was that the cost ought to be about a pound or so, at any rate to manufacture, and ten dollars, or something of that sort, the selling price. He did not think the process of manufacture was likely to bring them down so low as that in this country. He should think meters would be selling here in the immediate future for from £4 or £5 up to £18 or £20.

The CHAIRMAN (Mr. W. H. Preece) then proposed a vote of thanks to Prof. Forbes for his Paper. When thinking of the condition of electric lighting in this country one felt a great amount of depression, and it was only when listening to such Papers as that of Prof. Forbes, where they heard of the progress made in other places, that one felt that there was a possibility and a probability of that depression being removed. There was every prospect of it being removed in London, as we were now on the verge of a boom in electric lighting. The Commissioners of Sewers had now decided to issue at once specifications, to which tenders would be invited, to light up the whole of the City. It was hoped that tenders would be received from those who were competent to carry them out, and that before the end of the year Fleet-street, Ludgate-hill, and Cheapside would surpass the Unter den Linden. He agreed with Mr. Crompton that for fitting up private houses the proper candle-power to use was from eight to ten candles. Of course it would be absurd to light up the room they were now in with 8-candle lamps. Two things were wanted. They wanted to speak of the lamps not of so many candle-power, but of so many watts. The standard lamp that was being introduced, the standard lamp in his own immediate practice, was a lamp of fifty watts. Throughout the Post Office they commenced with 16-candle lamps; but they found that 10-candle lamps gave all the light they wanted. The second thing required was not the power of the lamp but the distribution of the light over the area. When they knew the amount of light they wanted on the surface of the work they were doing it was an easy matter to calculate whether the lamps should be of 30, 50, or 100 watts, because that simply depended on the position of the lamp and the distribution of the light upon the area below. He should like very much to join Prof. Ayrton in attacking Prof. Forbes upon the question of measurement, but it would be quite unfair to do so now, as Prof. Forbes would have no reply. They had been told that Mrs. Ayrton had been experimenting on a meter actuated by the principle of

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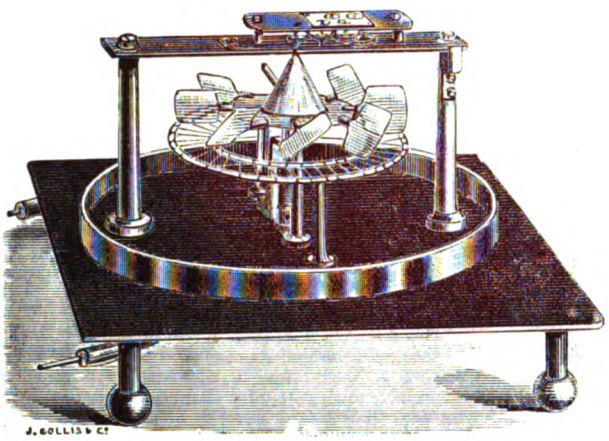
evaporation, water being used. Prof. Forbes, on the other hand, had introduced to them a very beautiful meter, dependent upon the evaporation of alcohol. The greatest benefactor in this instance would be the man, if he ultimately succeeded in producing a field where all the alcohol of the universe could be evaporated (laughter).

The vote of thanks was then carried by the meeting, and the proceedings terminated.

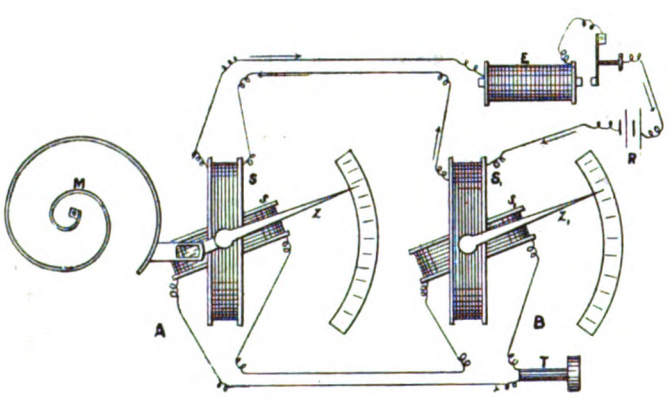
The illustration below represents the latest type of Forbes meter, which may be compared with the earlier type illustrated in our issue of February 8th. The following are the chief points of difference between the new and old types :—The wheel work is much lighter in the newtype; the conductor is of different form and of lower resistance, the spiral of wire being replaced by a number of cross



wires placed in parallel between two concentric rings. The point on which the mill wheel rests is more slightly rounded.

THE MŒNNICH INDICATOR.

We give below a diagramatic representation of a novel type of indicating apparatus, which has been devised by M. Paul Mœnnich, of the University of Rostock. M is the instrument whose move-



ments it is desired to reproduce at a distance. Some sort of flexible material, intended to undergo alterations in length, having some relation to the particular phenomenon (temperature, for instance), which is to be measured, is fixed to the coil s, and varies its position with regard to the external coil S. A similar arrangement exists at B, the point of observation. The coil s_1, which is wound in the reverse way to s, is in the same circuit as the telephone T and the coil s. The coil S_1 is connected to a battery, R, a trembler, E, and the coil S. Suppose the coil s to be in a certain position, the pointer z being at the corresponding division on the scale. If an intermittent current is sent along the line induction will cause noises in the telephone so long as the coil s_1 is not in the same position with regard to the coil S_1 as the coil s is with regard to the coil S. When silence is obtained s and s_1 are therefore in the same relative positions, and the position of the pointer z_1 will correspond to that of z. It is obvious that the principle is susceptible of a variety of applications.

THE ARON METER: LATEST TYPE.

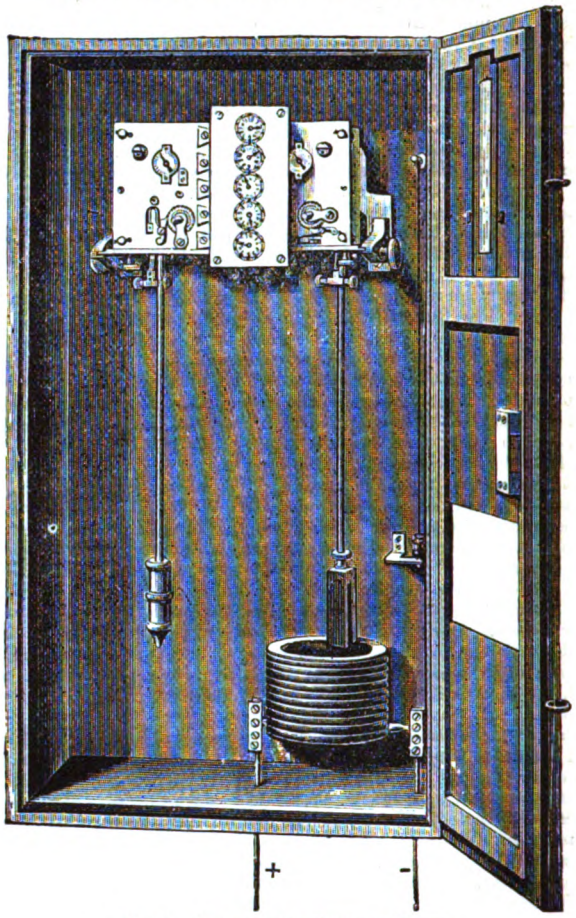


FIG. 1.—ARON DIRECT CURRENT METER.

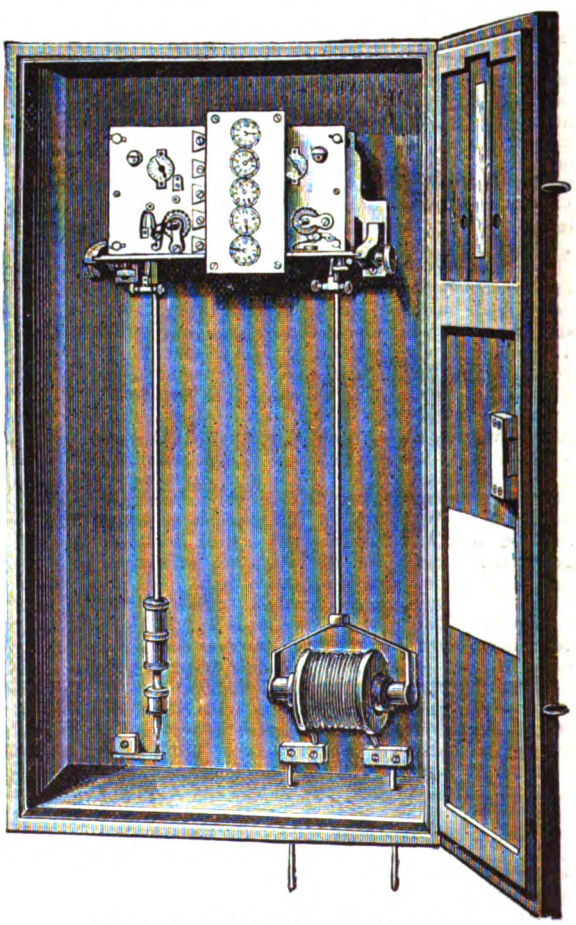


FIG. 2.—ARON ALTERNATE CURRENT METER

We illustrate herewith the latest types of the Aron meter for continuous currents (Fig. 1), and for alternating currents (Fig. 2).

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The following description will give an idea of the construction of the instruments:—In the direct-current meter (Fig. 1) two pendulums control two distinct clockwork gears. One of these is a standard, oscillating at a regular speed. The other has a permanent magnet instead of a weight, and is variable in speed. The variation is obtained by passing the entire supply of current to be recorded through a solenoid of thick wire placed underneath the magnet. The magnetic influence of this solenoid has an accelerating effect on the pendulum in direct proportion to the current passed through. The difference of speed between the standard and magnetic pendulum is given in direct ampere hours by differential speed counting gearing, on a similar principle as a gas meter index. The slightest alteration in the current passed through is thus recorded.

In the alternate-current type the principle is the same. One pendulum carries an ordinary metal weight, whilst the other one ends in the shape of a fork, which carries a coil of thin wire. This small coil is connected up in shunt, and moves freely inside a larger one, wound with thick wire, through which passes the main current. The effect of these two coils acting upon each other causes an alteration of the speed of the measuring pendulum, which is proportionate to the product of the existing E.M.F. and the strength of current. The clock went for six weeks without winding up.

The loss of E.M.F. with a current of, say, 100 amperes does not exceed 0·05 volt, owing to the small resistance in the measuring coil.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February 2nd*, 1889.

You have already been informed by cable and letter of the recent important decision of the United States Supreme Court in the Bate Refrigerator Company's case with regard to the effect of foreign patents on the term of United States patents. This decision, as has already been stated, has very direct bearing on a number of electrical patents, particularly those of Mr. Edison, as mentioned in my last letter. Under the circumstances, as might be supposed, the value of Edison Stock has risen very materially, and those who are interested in the Edison Company are quite elated and sanguine as to the final outcome of the suits when the patents are pushed to trial. The Edison lawyers in this city have not lost any time in availing themselves of the decision, but are already seeking to secure some of the fruits of it. They obtained an order in the United States Circuit Court this week, calling upon the United States and other Companies against whom action for infringement has been brought to defend themselves, and as the order is returnable this week it looks as though the various infringement suits would all be prosecuted actively. Now that the full text of the decision has been published by the electrical papers, it is seen that although the ruling is a very important one in many respects, it is not so altogether conclusive over the whole disputed field as might at first have been supposed. The Court, for instance, did not make any decision as to the exact meaning in the statute of the obscure words "first patented, or caused to be patented, in a foreign country." And it would appear from the phraseology of the decision as it stands, that if foreign patents had been granted for a short term and no extension had been obtained, the United States patent subsequently granted while the short term continued would certainly lapse at the expiration of that term. In fact, it would seem that the Supreme Court holds that the lifetime of the United States patent is affected solely by the expiration of the foreign patent, and that the term for which the foreign patent is granted upon its face has little or nothing to do with the matter. Here, however, a question might arise as to whether expiration would mean the end of the full term for which the patent was granted, or its sudden decease for want of sustenance in the shape of continued fees.

The interest that is being taken in electric railway work in all parts of the country grows every day, and it looks now as though the present year would see a general boom in this department. Two or three years ago the capitalists who were willing to interest themselves in electric railway schemes, and invested their money in them, were, as is usually the case, men of somewhat sanguine temperament and more enterprising than the rest of the community. They were often laughed at for their pains, and have been freely entertained with predictions of failure and disaster almost down to the present time; but with the increase in the number of roads, and the improvement in their methods of operation, there has been a most significant change of front on the part of those who were disposed to condemn such undertakings as hazardous and risky. Probably no more significant evidence of the new attitude towards the young industry could be found than that which is conveyed in the announcement that the Pennsylvania Railroad is about to put in an electric railroad at Atlantic City, N.J. This company is one of the largest and wealthiest of our railway corporations, and with the aid of a splendid engineering corps it conducts its system in a manner which often reminds tourists from the old country of the solidity and smoothness with which they are so familiar. It has recently been looking into the question of street railway operation, and has had an expert committee investigating the relative merits of the different systems of electricity, cables, &c. The inquiry lasted nearly six months, during which time the committee visited all the larger cable and electric roads in the country, and the outcome is that a contract for the building of the road at Atlantic City has been awarded to the Sprague Company, which is to put in an overhead system there. The effect of such an action as this upon the community at large must be great, for the Pennsylvania has never been known to approve thus heartily of a thing that was not very good, and it is always sure to find many followers. I should not be surprised a short time hence to find the Pennsylvania Railway Company employing electricity to operate some of its shorter branch lines on which it is now using the old steam locomotive.

In connection with the above remarks on electric railways, it is timely to note the great street tramway strike which has been agitating New York and Brooklyn for the last fortnight. The strike began in Brooklyn last week, and then spread to New York on Monday, since which time street tramcar service in this city has been practically suspended, while Brooklyn has been not much better off. If it were not for the elevated roads I do not know how business could be carried on, as they are virtually the only means of passenger transportation at the present time, except hacks, the hire of which, as many of your visitors to New York know, costs as much as the purchase of freehold estate in England. The magnitude of the strike may be judged from the fact that in this city alone over 6,000 men connected with the roads have left their work. In the meantime, of course, although no cars have been running, all the horses have to be fed, and their keep and care represents a very large item of cost. I do not know just how many horses there are engaged in street tramcar work in this city, but the number must reach several thousands. On the Broadway road alone there are close upon 2,000, or 12 to every car in service. One of the Brooklyn roads has no fewer than 3,000. Of course, if the roads in question were operated by cable or by electricity, the plant could be at once shut down, and there would be no expense or outlay on the score of power. But here, again, the advantage tends towards the side of electricity, for while the power required to run just one or two cars with electric motors would be strictly proportionate to the work done, in the case of a cable system, whether it were one car or a dozen, the road would have to carry its huge and heavy cable all around its system. It need not be wondered that under such circumstances the managers of our street railroads are inclined to look very thoroughly into the question of adopting electricity for motive power purposes.

An interesting new departure has been made during the present week in this city by the C. and C. Motor Company. They have moved into a magnificent new factory in Greenwich-street, where they will make their well-known motors, of which several thousands are now in use in this country, and of which I believe also a number have already been sold in England. The peculiarity of this building is that, although it is intended for manufacturing purposes throughout, no provision other than electrical has been made for the distribution of power. It is the intention to place motors on every floor according to the power that may be required there at any time. The generating plant is in the

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basement, where a huge 50,000 Watt-Edison dynamo is running all the time, furnishing current to every floor upon which it may be required. The whole of the extensive machinery of the company itself is thus run by their own motors, taking current from this generator, and on the floors which are leased for miscellaneous purposes the power is supplied in the same way. Thus, for instance, a manufacturer on coming into the building is asked how much power he wants and where he wants it, and he is immediately given that power in one motor or half a dozen in the exact position where it is most advantageous for him to apply it. It will readily be seen that such a system presents enormous advantages over the old method of supplying power by steam with its big belts and long lines of shafting, or by the even more expensive and annoying method of having a number of engines or steam plants all over the building. The building is well laid out, and wires are neatly run to each floor, and the whole works like a charm. It is also the intention of the company to distribute power from its generating plant to manufacturers in the neighbourhood. Altogether, this departure is a most interesting one, and it is attracting a great deal of attention.

The approaching convention of the National Electric Light Association at Chicago promises to be very large. It will be remembered that the association took its birth at Chicago three or four years ago in a modest way. In the interim it has visited for its semi-annual meeting several of our large cities, including New York, Boston, Philadelphia, Baltimore, Detroit and Pittsburg, and now goes back to Chicago with a large and vigorous membership to make a far greater impression on the West than it did when it began its work. There can be no doubt as to the good effect of these gatherings, though perhaps they come a little bit too often so far as the participants are concerned. Local interest and curiosity is aroused by the gatherings, the exhibition always attracting a great many spectators, and I believe in every instance the convention has been followed by local development of electric lighting and power. This month at Chicago the convention will be in the Exhibition building, and a very large and fine exhibit is to be made of electric lights, motors, and railway systems. It is believed that this will be very attractive to the people of Chicago, and hence arrangements have been made for the distribution of no fewer than 100,000 admission tickets. The good effect of this display on Chicago and the section of country around about it can easily be imagined, and there is every prospect that the convention will be fully as useful as any of its predecessors.

CORRESPONDENCE.

THE EFFECT OF CURRENTS UPON CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was much interested in the experiments of M. Firmin Larrogue, described in a leaderette in *The Electrician* for February 1st, but was somewhat surprised to find that his results seem to show that alternating currents produce a greater change in the molecular structure of a copper wire than do continuous ones.

About two years ago I was giving this matter some thought, and on making various inquiries among dynamo makers (one of them, at least, had a large experience) I found that they were of the decided opinion that the wire on the armature did not harden nearly so much, nor so quickly, as the wire on the field-magnets. This is with continuous-current machines. No tests have been made, and this is merely a statement of opinion. Of course the continual heating and cooling would alone tend to harden the wire; but this hardening would be greater in the armature, as it is usually at a higher temperature than the field-magnets.

About the same time the Grosvenor Gallery Company were good enough to let me have a sample of wire which had had an alternating current running through it for a very long time. I could not, however, find in it any trace of hardness other than that due to the slight coating of "rust" always found on wire, whether it has been carrying a current or not, after it has been for any length of time in an ordinary installation. After passing a piece of it through an annealing process it was apparently no softer than the original wire, which proved that there was in this case no "strain" in the molecular structure. These statements do not agree with the results obtained by M. Firmin Larrogue. In the case of the induction coil wire he mentions it would be interesting to know whether the effect might have been due to its having been boiled in impure paraffin wax or to its having been kept in the damp. The account of the wire taken from a lighthouse loses much of its interest owing to its not being stated whether it had been conveying a continuous or alternating current.

Perhaps the following will interest, as bearing on this subject:—Dr. Mouckman, for some experiments he was doing here, required a platinum wire in a perfectly annealed condition, which was tested for thermo-electrically (a very sensitive test); of course the method which naturally suggested itself was heating by means of a current, but he found it impossible to thoroughly anneal the wire thus, and had to resort to external heating, when there was no difficulty in getting the required result. He also found that when *once* the wire was annealed that heating it up by the current produced no strain. From this may fairly be argued that the current has a tendency to produce a strain in this sense, but that for such to become permanent, time is probably an all-important factor.

It would be interesting to know if the current has any effect on perfectly *pure* wires. It was from this point of view that the matter was interesting to me, as I was somewhat doubtful as to whether we should make our standard resistance coils from wires of alloys.

Some of your readers who have German-silver resistances in use on installation work (continuous and alternating current) may be able to say whether they harden or not. The coils should, however, not have been habitually heated.—Yours, &c.,

A. T. BARTLETT.

Cambridge, February 9th, 1889.

THE REGULATION OF DYNAMOS BY MEANS OF A THIRD BRUSH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the editorial columns of your journal, under date of December 21, mention was made of the recent Paper by Mr. Edward Caldwell upon "Third Brush Regulation of Dynamos."*

Since the topic is one which cannot fail to interest students of the dynamo, I may perhaps be permitted to say a word with reference to the machine with which his investigation was made. The dynamo in question is a small machine constructed for experimental purposes in this laboratory; but although it is not modelled after any existing commercial type, it possesses no peculiar features to which the results obtained by Mr. Caldwell can be ascribed.

When used as an ordinary two-brush series-wound machine, its characteristic, as given in his Paper, is a curve of the form which a properly constructed dynamo of that type should give The electrical efficiency, also, will compare favourably with that of large machines of our usual commercial types. Readers of Mr. Caldwell's Paper will, I am sure, agree with me in saying that the dynamo in question, under his management, showed unusual freedom from those perplexing idiosyncrasies with which the experimenter is apt to meet when he attempts to subject a machine to new and unusual conditions. In the systematic way in which, in the second half of the Paper, the "series" characteristic is modified, step by step, until the condition of complete regulation is reached and finally passed by, they will moreover recognise, I think, the development of a method which is applicable to *any* series dynamo.

The point to which I desire to call attention especially, however, refers to the position of the diameter of commutation during Mr. Caldwell's experiments, and the influence of changes of the same upon the direction of the current in the third brush line. The possibility of such an influence was recognised at an early stage of the investigation, and determinations

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of the distribution of potentials within the armature were made by explorations of the field under various conditions.

In the original thesis* in which these experiments were described, the curves resulting from these explorations are given, together with the readings upon which they are based. In view of the very simple explanation of the action of the third brush developed in the course of the subsequent measurements, this portion of the work was, unfortunately perhaps, omitted from the abstract published in the *Electrical Engineer* of New York.

I present, in the accompanying Diagram 1, one of these sets of curves, selecting an extreme case which will bring out the reaction of the armature at its worst, and the influence of the third brush circuit upon the strength of field and upon the distribution of potentials, when nearly one-third of the entire current in the armature was flowing through the third brush. The curves in question represent the result of a single set of galvanometer readings around the armature, subject to the irregularities due to slight changes of speed and to the various other minor disturbances incident to such measurements. Their trustworthiness in every important feature has, however, been established by repetition of the observations.

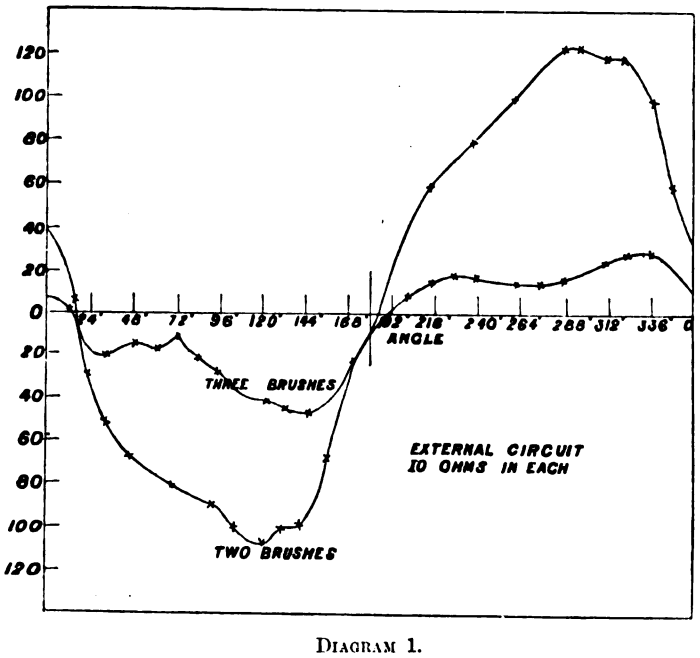

DIAGRAM 1.

In this case the reduction of the current is effected, as Mr. Caldwell has pointed out, by diverting the requisite proportion of current from the field coils and allowing it to pass through the third brush circuit. The current thus diverted amounted in the case in question to 0·90 ampere. Curve *b* Plate A shows the distribution of potentials under these conditions. The field is much diminished in intensity and the curve is modified, but the diameter of commutation has not changed appreciably, and the positive and negative brushes, with a lead of 12 degrees, need no readjustment.

The dynamo was first driven as a two-brush machine, giving 4·3 amperes through 10 ohms external resistance. This corresponds to a point well out upon the "series" characteristic, as will be seen by reference to Plate A of Mr. Caldwell's Paper. The brushes were given a lead of 12 degrees, which position corresponds very closely with the neutral points of the curve of induction (*see* curve *a*). The armature reaction is well marked but not excessive, and the distribution of potentials, to say the least, is fairly symmetrical for so small a machine. The third brush was then brought into place upon the commutator at a distance of 36 degrees beyond the positive brush, and the machine was adjusted for constant current at 1·70 amperes. The external resistance, as before, was 10 ohms.

* "Dynamo Regulation for Constant Current and Constant Electromotive Force, by Means of a Third Brush: a Thesis in Electrical Engine ering." By Edward Caldwell, M.S. in the library of Cornell University, 1888.

In another set of curves, which need not be reproduced here, the external resistance is 80 ohms. The position of all the brushes is the same as before. The function of the third brush in this case is, however, to strengthen the current through the field coils, and the adjustment is such as to send the current through the third brush circuit in the opposite direction. The curves show a much stronger field with three brushes than with two; the symmetry of distribution is still well preserved, and the shifting of the diameter of commutation is scarcely appreciable.

The principle upon which the experiments described in the second part of the Paper are based is extremely simple. Let a third brush be placed anywhere upon the commutator of a series-wound machine. A point in the external circuit can always be found, the potential of which will be the same as that of the third brush. If the brush be connected with this point no current will flow between them. Any change in the resistance of the external circuit will destroy the equilibrium however, and current will then flow through the third brush circuit. It is evident, moreover, that the direction of this current will always be such as to tend to the maintenance of constant potential at the terminals of the machine. Mr. Caldwell has pointed this out very clearly, and he has shown by experiment that very complete regulation for constant potential may thus be obtained. I have endeavoured to show, very briefly, that the dynamo with which his results were obtained does not differ from other properly-constructed machines of its class to an extent which would lead us to question the applicability of that method of regulation to all series-wound dynamos.—Yours, &c.,

EDWARD L. NICHOLS.

Physical Laboratory of Cornell University,
Ithaca, New York, January 21, 1889.

LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Owing to a press of work I have been unable to give, hitherto, more than a glance at the various letters and articles on the above subject originating with the Presidential Address of Mr. Preece before Section A of the British Association meeting at Bath last September, and which have been since continued in *The Electrician*. Considering the great importance of the subject, and the very wide field for ascertaining the precise nature of the electrical and atmospherical phenomena constituting lightning discharges, and the ample means which electricians, especially abroad, have of thoroughly studying them and taking exhaustive observations, it is indeed surprising that the field of discussion should have been so entirely left to Prof. Lodge, whose very clever and hitherto accurate experiments, however, must have met with the unanimous approval of all scientists, whether theoretical or simply practical.

It is to be regretted that any dissension whatever should have risen between the two camps thus constituted, because it must be admitted that the boastful axiom of "one grain of practice being worth a pound of theory" has been pretty well thrashed out of countenance, at least as far as electricity is concerned; and a careful examination of the whole discussion tends towards the fact of a misunderstanding having been produced by a certain quantum of acrimonious verbosity rather than a fixed antagonism of the question at issue. Mr. Preece, as an eminent practical electrician, has no doubt much reason to justify his depreciation of certain *soi-disant* theorists and mathematicians in embryo who have done so much to plague the life of a purely practical man; yet he would be the last one, I am sure, to undervalue the absolute necessity for proving the accuracy of any admitted practical fact by working it out in theory, and Prof. Lodge's valuable experiments are apparently tending not only to substantiate his own theories, but to prove that the practical man's lightning conductor is equally affected, although, until proper attention had been drawn to it, these phenomena were not observed. Hence it is that by a regular and general system of accurately recorded future observations we may hope to eventually arrive at a fairly correct solution of the disputed

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problem; and with the view of rendering assistance in this research, I propose to describe certain instances of lightning discharges which have, at different intervals, come under my direct personal notice.

The Eastern Telegraph Company's quarters at this station face the sea, and are separated from it by a mole some sixty feet away from it. At one corner of this mole stands a wooden flagstaff forty-five feet high, kept in position by a base socket hole one foot deep, a stone wall two feet cube, and four rope stays connected to an iron ring half way up the pole, and to the surrounding rocks below. This was erected in 1882, and as there was no record of the original flagstaff (which during the English occupation of the Ionian Islands, and under precisely the same conditions, had always stood there) having ever been struck by lightning, a guard was not considered necessary. Shortly afterwards, however, this flagstaff was destroyed by lightning during a storm of exceptional violence. It was purely a side stroke, the lightning falling on to the iron ring, smashing off the upper part, otherwise uninjured, and tearing away, in a groove-like spiral form, the lower part as far as the wall, which was split asunder; the rest of the pole, from the top of the wall to the base, was untouched, so that the discharge took an alternative route, and "splashed" into the sea after striking the wall. This was accurately proven at the time.

A similar pole was subsequently erected to replace the destroyed one, with a length of ordinary thick iron telegraph wire run up it and fastened into it by staples showing slightly above the top, the other end being in the sea. Many thunderstorms of varying intensity have occurred since then in the immediate vicinity of this house, but the pole has never suffered from them in the slightest possible manner, and it is to be assumed that the iron wire permits the entire discharge to pass along it, and owing to the small surface of the pole there is really little or no reason for it to errate by any alternative path, and thus the iron wire (its conductivity being, for this purpose, as good as copper, and, of course, immensely better than the wood) constitutes in this case a sufficient protection; and although the resistance of the "earth" is in ohms and not in microhms—about which a great amount of futile correspondence took place some time back—I do not hesitate to say that the pole is quite as safe as if it had one of the so-called orthodox lightning guards fixed upon it.

A still more illustrative example of this peculiar phenomenon occurred in Zante during a thunderstorm in February, 1886. A boatman was conveying a passenger to a steamer in port, and it was raining heavily, with occasional lightning discharges; the boatman was standing up facing the bows of his boat whilst rowing, the unfortunate passenger being seated in the stern sheets under a large cotton umbrella with a spiked metal ferrule to it. In order to reach the steamer the boat had to pass within a short distance of the dredger, a huge iron affair, with its lofty iron derrick wheels, chains and buckets all in position. When close off this dredger a lightning discharge, which, according to all theoretical and practical laws should have passed to earth *entirely* by the dredger alone, did not, however, do so, but part of it went by the alternative path constituted by the umbrella point, thence along or through the man's body to his knife stuck in his waistband behind, killing him instantaneously, singeing his clothes, and discharged itself through a nail in the side of the boat, which was there splintered and scorched. The boatman was stunned, but otherwise uninjured, and his version of the occurrence and an inspection of the body and the boat was taken by me within a few minutes of its happening.

About the same time I was asked by the surveyors to examine an English brig which had put into the port of Zante leaking from the effects—as reported by the captain and crew—of having been struck by lightning. The discharge must have been, from their description, one of great severity, and the inspection furnished undoubted proofs of its having been struck from the side. The mainmast was damaged from the lower yard-arm metal connections downwards, from whence a chain was hanging, and had been, intentionally or otherwise, twisted round the bilge pump right alongside of the mast. The weather vane and metal above the yard-arm appeared untouched. The leakage was caused by the discharge going down the chain and the pump, and then through the ship's bottom or side into the sea, but it had evidently "splashed" about considerably on reaching the deck, as everything metallic—notably, bolts and nails—seemed to have been affected by it, although, strange to relate, the captain, who was in the immediate vicinity of the mainmast, and who was temporarily blinded by the vividness of the flashes, was otherwise uninjured. It had not rained, however, previously, although the discharge was immediately followed by torrents of rain.

A final instance occurred last year. A one-storied house, situated on some rising ground behind the town of Zante, was struck by lightning, and a young man sleeping on the ground floor was killed. The discharge struck the external iron shutter fastener of an upper window facing the west, entering the room and leaving it by the inner and outer iron fastenings of another window on the same floor facing the north, from whence it went to earth by the outer wall. In its path to earth it met with the large iron-barred and closed window of the room in which the lad killed was sleeping upon a straw mattress on a dampish stone floor. A blue mark on his face and the discoloured features plainly showed where the derived discharge had struck him, and a rent in the bottom of the wall and the floor in the *opposite* corner where it had entered the earth.

These four cases, which I trust have been described with sufficient clearness, offer indisputable proof that lightning discharges follow precisely the laws relating to electricity and derived circuits, except that the ratio of discharge, owing to the intensely higher potential, and the electric inertia of the immensely larger surface of the building, compared with its protector, render the alternative path almost a necessity in certain instances; and it therefore follows that both theoretically and practically any building whatever having iron or copper bands of a sufficient breadth bound across the top and sides in four or more different directions, and connected to the—not necessarily "perfect"—earth would be far better protected than the same building having one single large copper conductor with a multiplicity of points and an earth of absolutely no resistance; and although there is not a shadow of doubt that Mr. Preece's observations about unscientifically constructed and uninspected lightning conductors adding to the danger unprotected buildings run are truisms, it certainly does not follow that they would enjoy absolute immunity from danger if they were alone protected by his orthodox lightning guard. If it were an absolute law that lightning discharges have an affinity for pointed objects only, it is an astonishing fact that ships are not more frequently struck than they are, considering how constantly they are subject to their influence, and how small is the proportion furnished with lightning protectors, and that every craft all over the world has some insulated metal connection or another aloft. May we not rather assume that the electric inertia of the *mass* carries off the entire discharge, leaving the points as the very feeble alternative path?

In England and America we may be pretty certain that lightning conductors are fairly well constructed and periodically inspected; abroad this is the exception, not the rule. Yet all the world over do we not find that, considering the immense disproportion in the number of protected buildings compared with unprotected ones, the cases of damage are as frequent, if not more so, in the former than in the latter? In many parts of Europe, in Italy, and all over the Levant especially, it is the rule to have high churches and other towers surmounted by a long metal weather vane or a huge iron cross, and yet instances of their being struck seldom or never occur; on the other hand, I remember that when the powder magazine at Scutari, in Albania, was struck some years ago, it transpired on the inquiry that the whole of the lightning conductors, *except the points*, had been removed, the wires to earth being considered unnecessary.

In 1883, when in Corfu, I was asked by the Prefect to examine the lightning guards on the powder magazine at the castle, and I found them entirely disconnected from the earth, and they had evidently been so for many years; whilst a final instance we have in Zante, where at the signalling station up at the castle—700 feet high—they have a hollow iron telescopic flagstaff raised on the top of a wooden pile driven into it and into

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the ground in order to increase its height, and a stone wall built up flush with the base plate; yet up to the present it has never been damaged.

In conclusion, I would state that on one occasion I happened to be in a wooden-lined iron cable house during a terrific storm, and with the lightning playing all around it. The sense of security, when inside, is perfect, and as Sir Wm. Thomson says, the safety *is* absolute, whether that hut be built on the rock or on the so-called "perfect earth," provided, however, it and you are quite dry; but I confess that I would as soon think of holding a perfectly constructed lightning conductor during a storm as be wet through and on a wet floor inside an iron hut.—Yours, &c.,

W. G. FORSTER,
Manager and Electrician, Eastern Telegraph Company.

Zante, January 17, 1889.

GLOBULAR LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Globular lightning is the electricians' sea-serpent. It has several times been scotched, and always appears in the "silly season," when Parliament is not sitting and electricians have nothing better to do than utter platitudes about insulation resistance. While not denying the great interest attaching to this most mysterious of electrical phenomena, I must enter a protest against the appearance of more than one globular story in one number of *The Electrician*. Last week there were actually two such stories; it is too much. On page 390 is a note to the effect that M. de Paulpiquet had half a lightning ball fixed on his horse's chest. I firmly believe in M. de Paulpiquet; his account bears internal evidence of its truth, for he tells us the horse died from the effects. Of course it did—what horse could survive lightning on the chest?

Some years ago a description appeared in *Nature*, I think, of a fiery globe which, after chasing a French gentleman for several minutes, exploded, leaving a quantity of mercury on the floor. That story also must be true, otherwise one cannot account for the mercury. In short, I believe all such stories when they come from France; but how can Mr. Fahrig (page 413) expect us, just after swallowing the horse affair, to believe his somewhat excited description of the several meteorological phenomena witnessed by him? Item: "A fireball *two* metres in diameter." One cannot but admire the intrepidity which enabled Mr. Fahrig to risk certain death in order to make an exact measurement of the diameter! Item: Bluish, fiery light. It would be likely to be fiery seeing where it came from. Item: An explosion lasting *two* seconds. Item: A snowstorm, which in *two minutes* deposited 1½in. (oh, why not 2in. !) of snow on the ground.

Now, sir, last Sunday I was in the country, and for over two *hours* it snowed hard without stopping. I thought of Mr. Fahrig, and measured the snow in three or four places; average depth about 1½in. However, I have it from two quite independent sources that a brilliant flash of lightning, followed by sharp thunder, was observed *during* a snowstorm at Stamford Hill, on February 2nd, so that there may be a place in history for Mr. Fahrig's fireball if he will kindly reduce its diameter to circular measure, and state the elements of its orbit somewhat more precisely. We will make allowances about the snow. I almost saw a fireball myself once; it was terribly exciting.—Yours, &c.,

SYDNEY EVERSHED.

CONSTANT-CURRENT REGULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly permit us a line on the so-called Edmunds method of maintaining constant currents, and as to the information lately received that Marcel Deprez was the first to explain the theoretical principle on which this regulation for constant-current is based.

This principle was first applied by our engineer, Mr. Joseph Kirkham, in the year 1884, with results equally satisfactory as those recorded by your correspondent in the February number of *The Electrician*, page 379.—Yours, &c.,

JOHN SMITH AND CO.

Moscow, 28th Jan.—9th Feb., 1889.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

January 14, 1889.

656. W. H. DINES and L. W. GATWARD. Hitchin. Measuring the quantity of a direct or alternating current of electricity.

706. M. R. WARD. London. Electric accumulators.

January 15, 1889.

731. W. J. BREWER. New York, U.S.A. Improvements in conduits for cable and electric railways.

746. O. LUGO. London. Improvements in and relating to electric secondary batteries or accumulators.

757. C. J. VAN DEPOELE. London. Improvements in and relating to a system of suspended bare wires, travelling connections between the said wires and the motor and switches, &c., in and for electric railways. (Date applied for under Section 103 of the Patents, &c., Act, 1883, Aug. 9, 1888, being date of application in the United States.)

759. C. H. WELLS. London. Improvements in switches for electric railways.

765. C. D. ABEL. London. Improvements in type printing telegraph apparatus (Messrs. Siemens and Halske, Germany).

January 16, 1889.

811. J. GARTON. Lancashire. Improvements in the mode of application of magnetism and electricity for medical purposes.

813. W. DIEHL. London. Separation of aluminium and its alloys from its fluorides by electric or by chemical metallurgic process.

January 17, 1889.

859. H. F. JACKSON and D. SINCLAIR. Glasgow. Improvements in telephonic apparatus.

895. J. C. FULLER and G. FULLER. London. An improvement in or connected with electrical connections for burglar alarms.

898. G. C. HALE, A. BARRETT and J. ZENTNER. London. Combined fire alarm and telephone telegraph. (Date applied for under Section 103 of the Patents, &c., Act, June 27, 1888, being date of application in the United States.)

915. S. ZIANI DE FERRANTI. London. Improvements in electric switches.

January 19, 1889.

983. C. ADAMS-RANDALL. London. Improved electric time alarm and indicator.

997. T. CUTTRISS. Leeds. Improvements in secondary or storage batteries.

1,006. P. COOTE. Brighton. Improvements in electrical pole changers.

1,018. G. E. ADLER. Croydon. An improved method and apparatus for facilitating the working of telegraph instruments.

1,031. J. W. KING. London. Improvements in dynamo electric machines.

1,038. J. P. REES. London. Improvements in and relating to electric lamps for signalling purposes.

1,047. M. R. WARD. London. Improvements in propelling vehicles by means of electric motors.

January 21, 1889.

1,056. T. PEASE. Liverpool. Improved electrical storage battery.

1,057. C. ADAMS-RANDALL. London. Improvements in electric date and and time hand stamps.

1,101. W. LOWRIE and C. J. HALL. London. Improvements in and relating to underground mains for electric conductors.

1,103. W. LOWRIE and C. J. HALL. London. Improved system of distributing pipes or conduits for containing the supply conductors for electric lighting.

1,112. E. GWOSDEFF. London. Improvements in simultaneous telephony and telegraphy.

1,113. E. GWOSDEFF. London. Improvements in long-distance telephony.

January 22, 1889.

1,118. E. A. SPERRY. London. Improvements in apparatus for automatically switching loop circuits out of or into the main electric circuits.

1,166. W. LOWRIE and C. J. HALL. London. Improved method of and means for testing the insulation of electric conductors.

1,167. W. LOWRIE and C. J. HALL. London. Improvements in and relating to switches and switch connections for electric circuits.

1,168. W. LOWRIE and C. J. HALL. London. Improvements in electric current switches.

1,169. G. E. RUTTER. London. An automatic electrical machine for the delivery of prepaid articles.

1,190. LAURENCE, PARIS and SCOTT (Limited) and W. H. SCOTT. London. Improved means in connection with electric current transformers for regulating the electromotive force in the working circuit.

January 23, 1889.

1,216. G. E. FLETCHER. Edgeley. Automatic contact maker and breaker for electrical circuits.

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1,229. W. R. Rawlings and J. J. Rawlings. Manchester. Improvements in adjustable suspending devices for electric incandescent lamps.
1,236. B. Verity. London. Improvements in underground conduits or channels for electrical conductors.

January 24, 1889.

1,341. C. Wells. London. An improved electrical indicator.
1,343. F. H. Nalder, H. Nalder, C. W. S. Crawley and A. Soames. London. Improvements in instruments for measuring electricity.

January 25, 1889.

1,358. J. G. Cumming. Edinburgh. Improvements in electrical coin-counting, valuing and checking machines.
1,401. J. T. Dyer, P. Fish and R. C. Fish. London. Improved mode of generating electricity by dynamo-electric machines.
1,420. F. King. London. Improvements in secondary batteries.
1,421, G. A. Sykes. London. New and useful improvements in voltaic electric belts employed as medicinal agents.

January 26, 1889.

1,454. H. F. Joel. London, E. Electric meters.
1,456. V. G. Sironi. Leytonstone, Essex. Improvements in electric traction.

1888.

18,035A. Sir William Thomson. Glasgow. An improved ampere gauge and connections, part of which are applicable to other electrical appliances. [Note.—This application having been originally included in No. 18,035, dated December 11, 1888, takes, under Patents Rule 23, that date.]
18,035B. Sir W. Thomson. Glasgow. Improved apparatus for continuously measuring and recording potentials or currents. [Note.—This application having been originally included in No. 18,035, dated December 11, 1888, takes, under Patents Rule 23, that date.
18,035C. Sir W. Thomson. Glasgow. Apparatus for regulating electric potentials or currents. [Note.—This application having been originally included in No. 18,035, dated December 11, 1888, takes, under Patents Rule 23, that date.]

SPECIFICATIONS PUBLISHED.

Week ended January 23, 1889.

1888.

531. Edmunds. Generating, &c., electricity. (Price 11d.)
2,525. Richardson. Arc electric lamps. (Price 8d.)
2,586. Kennedy. Incandescent electric lamps. (Price 8d.)
2,698. Dove. Sanitary and magnetic mattresses. (Price 8d.)
2,784. Imray (Imray). Electrically lighting railway carriages. (Price 8d.)
2,785. Lauckert. Electric glow lamps. (Price 8d.)
2,794. McEvoy. Electrical firing keys. (Price 8d.)
8,700. Renard. Electric batteries. (Price 8d.)

Week Ended January 30, 1889.

1888.

1,707. Fergusson. Recovering zinc, &c., from liquors of batteries. (Price 6d.)
2,772. Hedges. Electrical safety appliances. (Price 8d.)
2,933. Haddan (Hill). Regulating dynamos. (Price 8d.)
3,223. Kingsland. Secondary batteries. (Price 6d.)
17,008. Schiodt. Dynamo machines. (Price 6d.)
17,063. Haguet. Electric spray producing apparatus. (Price 6d.)

Week Ended February 6, 1889.

1888.

249. Roe. Measuring electric currents, &c. (Price 8d.)
1, 24. Pyke and Barnett. Electric coils. (Price 8d.)
3,072. Rhoades and Ticehurst. Automatic electric induction apparatus. (Price 8d.)
3,515. Collett. Telephonic apparatus. (Price 8d.)
9,254. Drake and Others. Controlling devices operated by the thermic effects of electric currents. (Price 8d.)
14,772. Redfern (Brillie). Measuring electric currents. (Price 8d.)
17,688. Short. Electric railways. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

The India-Rubber, Gutta-Percha and Telegraph Works Company (Limited).

The twenty-fifth ordinary general meeting of the shareholders was held at the City Terminus Hotel, Cannon-street, on Thursday, Mr. S. W. Silver, the Chairman of the Company, presiding.

Mr. WILLIAM J. TYLER (the Secretary) read the notice convening the meeting. The report and accounts were taken as read.

The CHAIRMAN said: I think, gentlemen, the report embodies much or most of what I have to say. Nevertheless, I may in a general way refer to the circumstances under which we are met to-day, as compared with twelve months since. The general trade of the country has increased, and I am thankful to say that the operations of this undertaking have expanded fully in proportion. We have passed through a year of trade in which our general sales have equalled and exceeded those of any previous year. Here, I may venture to say, we have evidence of the prepared state of our works for any demand that may be made upon them, which I think we may attribute that to the prudent judgment and the energy and ability of the members of the staff. In making that remark I certainly cannot pass over my friend on my right (the Managing Director), who gives to this concern, I may say, the best hours of his life. So far as regards that side of the question. There is another side of equal importance to us, largely interested as we are, and that is as to the profit. Owing to the keen competition we meet with in beaten tracks I am not in a position to say that the profit is at all in accordance with the amount of sales; nor must we look for it, unless we go into new fields and seek out new outlets, such as those appliances connected with electricity. There are many and varied openings in connection with electric lighting, and so on; and I am glad to tell you that our works, as far as that branch is concerned, are well employed. We have as the result of the year's operations a net profit of £57,157. That amount, with the sum brought over from 1887, shows a total of £66,687, out of which we recommend a payment of 10s. per share as dividend, in addition to that paid last July, which will make up upon the year 10 per cent., and enable us to carry over £25,000 to next year's account. Now, that is a very useful sum to us. Our stock at times has to be supplemented so as to take advantage of the offers that are made to us of raw material. We come now to the submarine branch. We have done little there as compared with our resources in staff and plant; but I am glad to tell you that we are now very much better employed, and are likely to be for months to come, and our vessels will then have something to do. No profit, however, has been taken on account of these new cables. As regards all the other branches, we are in a generally efficient state at Silvertown, and the same may be said of Persan-Beaumont, which shows an improvement on last year in its operations. With these remarks I think it only remains for me to move:—

"*That the report and accounts now presented be received and adopted, and that a dividend of 5 per cent., or 10s. per share, income-tax free, payable on and after the 15th inst., be now declared.*"

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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Mr. ABRAHAM SCOTT seconded the motion.

The CHAIRMAN: We shall be glad to hear any remarks or to answer any questions.

Mr. LAMONT: May I ask whether the steamers have been earning anything during the past year? You say they have had very little to do.

Mr. COCHRAN: Before you answer that question Mr. Chairman, I should like to make a remark or two. I think I shall be in the recollection of the shareholders who were at the meeting in 1886, that serious objection was taken to one of the conditions you asked the shareholders to authorise, and that was that no objection could be taken to the Directors' remuneration unless proposals were submitted to the Board seven days before the general meeting. To meet that difficulty, and in order that there might be no split, it was decidedly the feeling of the meeting, and an undertaking was entered into by your predecessors, that ample notice should be given of all future meetings of the Company, and that the report should be issued in sufficient time to enable any shareholder who might wish to take objection to these remunerations to lodge a notice. Now, I have to draw attention to the fact that this arrangement, no doubt through an oversight, has been overlooked, for this report was issued exactly a week prior to the meeting. I think this ought certainly to have been obviated, and I think the time has come for us to consider whether the remuneration which we are paying to our Directors is a reasonable one. The fees of the Directors are charged in the accounts on this occasion £3,728, which, distributed among five gentlemen, comes to just about £750 each. I submit, gentlemen, that while we ought to pay the gentlemen who are managing our business a fair and reasonable remuneration, with the ample and notoriously efficient staff and the able management of this Company, we are paying our Directors decidedly too much. It is very nearly 10 per cent. upon the whole amount that the Directors are distributing among the shareholders. I know I am out of order, because I cannot move a resolution to-day owing to the circumstance I have referred to; but I call attention to the matter for two reasons. I think the Directors would act wisely in meeting the shareholders and agreeing that this excessive amount should be reduced. There were reasons why such a large amount was paid in previous years, but those considerations I feel no longer hold now, and I think the shareholders ought to have some revision of this scale. We have, we all know, an admirable Managing Director, to whom we have all looked for the wise conduct and management of this concern, and we also clearly recognise that our Directors ought not to be paid shabbily; but I submit that the time has come when this arrangement ought to be revised and a fresh scale submitted.

A SHAREHOLDER: I received lately from the Gas Light and Coke Company a list of subscriptions to the North Woolwich Gardens, and I see, gentlemen, that you have subscribed £500 out of the funds of the Company, which I think was hardly in place, seeing the condition we are in.

Mr. TOYNTON: I notice that the gross profit and the interest and profit on debentures and shares in other companies are lumped together in one sum. In previous years they have been divided. May I ask whether there is any objection to the separation of them?

Mr. EVENNETT: I should like to refer to the item of debentures and shares in other companies. Will you explain the difference between the amounts in the last two accounts?

The CHAIRMAN: As you suggest, Mr. Lamont, the steamers have done comparatively little work during the past year. Then, in reply to Mr. Cochran, I may say that a shareholder can give notice of any alteration. As regards the shortening of the time on the present occasion, we had the interests of the shareholders in view in holding the meeting one week earlier than we might otherwise have done. The delay in holding the meeting was complained of last year. As regards the subscription to the North Woolwich Gardens, that seems to us to have a very ready answer. It is in the interests of our workpeople. I am afraid, sir, you do not know the pest that garden was to the neighbourhood. If you knew the neighbourhood as we all do here, you would be thankful to promote the removal of it and the application of the space to a far higher and better purpose. As you are aware, we have a number of people down there, and their interests we are very careful in watching. Now, as regards the gross profit, that includes the profit on the sale of some of the securities we held last year.

A SHAREHOLDER: Is there any objection to give the separate amounts?

The CHAIRMAN: Yes, there would be an objection. We are a trading company, and there would be an objection to giving details. We have sold some securities during the past year, and that explains the difference between the items last year and this.

Mr. LAMONT: I suppose our steamers are not very useful for ordinary commercial purposes. It seems a pity otherwise that four steamers should lie idle earning nothing. There is another point. We all know how soon machinery becomes antiquated nowadays; but do you consider that the allowance of £13,000 keeps machinery quite up to the mark at the present day?

Mr. MATTHEW GRAY (Managing Director): In reference to our ships, I may say that they are not suitable for ordinary cargo ships. They are fitted up with cable machinery, and are filled with tanks, so that to take these out and make them suitable for cargo ships would be very expensive; and it would be very expensive to replace them and fit them up. We have been very anxious to utilise the steamers as far as possible, and we tried one voyage. The result was that we lost nearly £2,000. We got nothing for the hire of the ship, and we lost nearly £2,000, with all the care we could take. In reference to the machinery down at the works, I may say, with the utmost confidence, that the machinery is in first-rate order. I think any of the shareholders who may go down to the works, if they have any knowledge of machinery at all, will at once see that everything is in very good order indeed. I could not control the thing at all if we had not the first-rate workshop and workpeople we have. They are at least second to none in the country, I do not care where they are.

The motion was then put and carried unanimously.

The CHAIRMAN: It now devolves upon me to propose the re-election of two of our directors, Mr. Scott and Mr. Henderson.

Mr. GRAY: I have much pleasure in seconding that.

The motion was also carried.

Mr. LAMONT moved the re-election of Mr. Weise, the auditor, at a fee of 30 guineas, and said: I think at this time last year some remark was made as to the character of the certificate given by the auditor; but I see that this year it is about as full as could be expected.

General TREVOR: As I was the gentleman who wished on that occasion to have a more full certificate, I have great pleasure in seconding the proposition.

The auditor was thereupon re-appointed.

A vote of thanks was passed to the Chairman and Directors, and the meeting then closed.

NEW COMPANIES REGISTERED.

THE RIVER PLATE ELECTRICITY COMPANY (LIMITED).—Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, London, E.C. Capital £500 000, divided into 49,900 shares of £10 each, and 1,000 shares of £1 each. Object, to enter into and carry into effect the agreements made with Walter Richard Cassels, and with the Rosario Electric Lighting Syndicate, to generate, produce, and deal in electricity or electric force for lighting or other purposes. The first directors shall be appointed by the subscribers to the Memorandum of Association, and shall each hold at least 50 ordinary shares in the capital of the company. The remuneration shall be the sum of £1,000 per annum, and one-tenth of the surplus profits remaining after payment of 10 per cent. per annum.

CITY NOTES, &c.

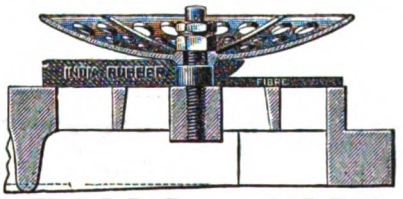
BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 8th amounted to £4,871.

SUBMARINE TELEGRAPH COMPANY.—The accounts for the half year ended the 31st December, 1888, enables the directors, after adding 15 per cent. of the gross receipts to the reserve fund, to recommend a dividend at the rate of 16 per cent. per annum, which compares with 15½ per cent. a year ago.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 8th, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £3,772.

NEW VALVE

No Rubber, Percha, or Leather.



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"12, John-street, Sunderland, 26th Sept., 1885.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Feb. 13, 18·9.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Feb. 13, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	7/6	Anglo-American	50 51	2 13 5	Jan., Apr., July, Oct.	50½	50
2,614,820	Stock	15/0	Do. Preferred	84½ 85½	3 16 0	,, ,,	85¼	84½
2,614,820	Stock	5/0	Do. Deferred	17 17½	...	February	17	...
130,000	£10	3/0	Brazilian Submarine	13⅝ 13¾	5 0 11	Mar., June, Oct., Dec	14	13⅝
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 15	6 0 0	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9¼ 10¼	3 19 0	Jan., Apr., July, Oct.	10	9⅞
380,000	10	2/6	Eastern	12⅞ 13⅛	4 11 5	,, ,,	13 1/16	12 13/16
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	15 1/16	14 13/16
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	...	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	108	...
250,000	10	2/6	Eastern Extension	13 13½	4 18 4	Jan., Apr., July, Oct	13 1/16	13
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	101 104	4 16 2	January and July	101	...
179,177	10	1/3	Globe Telegraph and Trust	7 7½	4 16 7	Jan., Apr., July, Oct.	7½	7
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14 9/16	14⅜
150,000	10	5/0	Great Northern	14⅜ 15¼	4 18 6	Jan., July, and April	15⅛	15
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	40	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	6⅞	6 9/16
15,609	10	3/0	West African Telegraph	6½ 7½	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	100 103	4 17 1	March & September	...	...
30,000	10	6/0	West Coast of America	9 9½	6 6 4	January and July	9¼	9
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅝ 1⅞	...	...	1⅞	1⅝
34,563	10	12/0*	Do. 1st Preference 6%	11⅛ 12	...	April and October	11⅞	11 13/16
4,669	10	+	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	12⅞ 13⅛	...	March & September	13⅛	12 15/16
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅝ ¾	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	13/16 15/16	3 2 11	...	...	...
80,000	5	5/0	United	14⅛ 15	5 0 0	June and December	15	14⅝
55,000	5	3/0	United River Plate	5½ 5¾	...	January and July	5¾	5 13/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3⅛ 4	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4½ 5	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅝	...	...	2 7/16	...
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	12/0	Telegraph Construction and Maintenance	42 43	5 11 7	March and July	...	...
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	18 19	5 5 3	February & August	18⅞	18⅝

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

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NOTES.

The Court of Appeal delivered judgment on Monday last in the case of the Edison-Swan Company *versus* Holland and others, reversing the decision of the Court below and upholding the Edison patent. The Anglo-American Brush Company who appeared at the trial as "third parties" were condemned in costs, but the Court refused to issue an injunction against them or to order an inquiry as to damages, drawing a distinction between "third parties" and defendants in the suit. The result appears to be that the Edison-Swan Company would have to bring a fresh action in order to prove infringement of the patent by the Brush Company, but, as will be seen from the note below, this would involve some rather singular consequences. Meanwhile, we learn that the Brush Company has already given notice of their intention to appeal to the House of Lords.

It may have occurred to some of our readers to wonder why the Edison-Swan Company did not serve a writ upon the Brush Company in the first place, instead of attacking them through their customers. But thereby hangs a tale. The facts are these: Some time before the present action was commenced the Brush Company thought it would be wise on their part to secure the services of the three eminent counsel—Sir Richard Webster, Mr. Aston, and Mr. Moulton, and accordingly retainers were duly offered and accepted. Shortly afterwards the Edison-Swan Company—who were evidently alive to this transaction—entered their action against Holland, and the same three above-named eminent counsel—Sir Richard Webster, Q.C., Mr. Aston, Q.C., and Mr. Moulton, Q.C., knowing nothing of Holland, accepted retainers on behalf of Edison-Swan. When, therefore, the Brush Company, in spite of the opposition of the plaintiffs, succeeded in being made "third parties in the action," the three aforesaid eminent counsel found themselves in a decidedly queer position. The Brush Company was by no means willing to relinquish its claims upon their services—neither were their opponents. However, an understanding was eventually arrived at on this point of etiquette, and in the action against Holland the three eminent Q.C.'s appeared on behalf of the plaintiffs. But now comes the rub: If the Edison-Swan enter an action against the Brush Company to prove infringement and obtain damages, then the three eminent counsel who have hitherto so ably championed their rights will be found on the side of the alleged infringer! In such a case we should be prepared to witness a display of forensic ability of a most interesting, not to say entertaining, character.

Mr. Kennelly is to be congratulated on the very interesting and unique problem which the trouble on the Halifax cables has presented for his investigation, and we may add that there are not many electricians who would have grappled with its difficulties so successfully and thoroughly as Mr. Kennelly. The Paper read last night before the Institution of Electrical Engineers furnishes an admirable example of scientific method, and merits the careful attention of every student of submarine telegraphy.

A short time ago Mr. F. H. Blakesley read before the Physical Society an important Paper "On Some Facts Connected with the Systems of Scientific Units of Measurement." Mr. Blakesley "thinks it will be conceded that even the most hardened physicist feels some pangs of passage on the troubled sea of transformation from the *terra firma* of the electrostatic system to that of the electro-magnetic;" and we print further on the formula by which he proposes to effect the transition with the minimum of anguish. Mr. Blakesley, however, further points out that by making "v" the unit of velocity, the two systems would coalesce. This is only 30 times the present unit of velocity in the practical system, and it would merely involve making the unit of length 30 quadrants, or else the unit of time would be only $\frac{1}{30}$ second. He has also made the curious discovery that the reciprocal of the specific heat of air under constant pressure (·2382) is very approximately equal to 4·2, which is the well known numeric in Joule's equivalent, or the number of 10^7 ergs required to raise one gram of water 1° C. If, therefore, we take air instead of water as our standard of specific heat, we shall get the dimensions of temperature in terms of centigrade degrees expressed as a decimal number; in fact, 1° C. = 10^7 of one C.-G.-S. (air) unit. The author discovers some other curious numerical coincidences which it would certainly be well to recollect whenever we make up our minds to a reform in the present cumbersome system. As Mr. Blakesley remarks, this system is already twenty years old, and it is scarcely surprising to find that it does not fulfil all the wants of the present day. The Paper, which is full of interesting points, will be found in the *Phil. Mag.* for February. We cannot resist quoting the concluding passage as follows:—

"Dr. Whewell entertained a speculation as to whether the laws of motion would ever have been discovered by an intellectual race of jelly fish inhabiting a world in which were no social bodies. In like manner we may imagine that had Torpedoes, or other animals armed with a controllable electrical equipment, won the race for supremacy against man, the laws of electricity might have been reached before the mecha-

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nical laws. Faraday and Maxwell would have preceded Galileo and Newton, and Gymnotus might have exhibited in submarine air-cases that uncanny biped Homo who could give you a curious and mysterious shock with a stick or a stone."

THE measurement of "v" by Sir WILLIAM THOMSON and Profs. AYRTON and PERRY, communicated to the British Association at Bath, was too small (292), on account of the accidental omission of a correction regarding the effective area of the attracted disc in the absolute electrometer. We now learn that when this correction is applied their result is brought up to 298, which exactly agrees with Profs. AYRTON and PERRY's previous determination by another method in Japan. Prof. J. J. THOMSON's result is 296·3. It is understood that ROWLAND has found 299. The result of Sir WILLIAM THOMSON's latest observations, founded wholly on the comparison of electrometric and electromagnetic determinations of potential in absolute measure, is 30·1 legal ohms, or 31·04 Rayleigh ohms. Assuming, as is now highly probable, that the Rayleigh ohm is considerably nearer than the legal ohm to the true ohm, the result for "v" is 300·4 million metres per second. Sir WILLIAM does not consider that this result can be trusted as demonstrating the truth within $\frac{1}{3}$ per cent.

MR. KAPP'S Paper on Alternate-Current Machinery (read before the Institution of Civil Engineers on Tuesday last) was worthy of the high reputation of the author. The subject is one upon which Mr. KAPP'S combined practical and theoretical acquaintance is at present probably unequalled in the profession. We postpone any further remark until after the publication of the Paper and the discussion in the *Journal* of the Institution.

IT would be strange indeed if the country which was first to make use of OHM'S name to designate the unit of resistance, and which has profited by his great discovery probably more than any other, had not been invited to join in a movement to do the illustrious German honour in his own country. The memorial, in the shape of a statue, which is to be erected in the city of Munich, will, in any case, be a well-deserved recognition of the fundamental service which the discoverer of "Ohm's Law" has rendered to electrical science and industry. We mentioned last week that the Royal Society has taken the matter in hand; a large committee has been formed, and the warmth with which the proposal has been responded to already affords assurance that, so far as England is concerned, the memorial will be worthy of the man.

THE full report now to hand of Dr. STEPHAN'S speech announcing the acquisition of the Anglo-German cables by the German and British Governments mentions the sum of 6,300,000 marks as the price paid by the first-named Government for its proportion of the purchase, a similar arrangement having been entered into on the part of the English Government. Much satisfaction was expressed by the German Minister of Posts and Telegraphs at the bargain he had been able to make, and the probable conclusion of arrangements with regard to the Belgian and Dutch cables on a like basis. A substantial reduction of the tariff is promised, and additional means of communication foreshadowed at no distant date, connecting Germany with the chief shipping and mercantile ports of Great Britain.

IN strong contrast with the above, the French Government are still raising difficulties about the purchase of the Anglo-French cables, and it is reported that no reduction of tariff is contemplated on those lines, whether they are purchased or are superseded. The conduct of the French Minister is, from every point of view, most extraordinary, especially as a considerable amount of the Submarine Company's stock is held by French men, who, of course, are as much interested in a liberal settlement as are the English shareholders. It will be remembered that it was the French Government that expressed its willingness to renew its concession to the company, and we heard nothing then about its cables being worn out and incapable of carrying the traffic. The English Government interposed, declining to be a party to the further concession, but raising no objection, so far as we have heard, to the company's property being bought at a fair price. Hereupon the French Government discover that the cables are not worth buying, and threaten to let them be abandoned as old iron at the bottom of the Straits. No doubt the Governments of the two countries would be within their strict legal rights if they declined to use the old cables; but all the same it would be an act of confiscation for which there is no moral or practical justification, for in reality the cables are worth a good deal where they are, but would be worthless if taken up. It is to be hoped that on this question Mr. RAIKES may now display as much firmness in demanding fair play for the English Company as he did in obtaining fair play for the English public when the renewal of the concession was under discussion.

The Electrical and Industrial Exhibition which is to be held in the Bingley Hall at Birmingham during the months of August, September, and October ought to become the exhibition of the year so far as this country is concerned. Nor do we think that its prospects are any the worse by reason of the competition of the Paris show. Our New York correspondent has more than once informed us that we may this summer anticipate the visit of a very large number of American electricians, on their way to and from Paris, and no effort should be spared on our part to make the Birmingham Exhibition worthy of the attention of our American friends. So far as the local managers are concerned we are convinced that every possible effort will be made to ensure success, and the rest must devolve upon the exhibitors. We may add that the long list of "Patrons" is headed by the MARQUIS of SALISBURY. The schedule, so far as yet arranged, will be found in a further note.

WE have often felt a lamentable inability to do justice to the humorous side of science, and never more so than on perusal of an article which recently appeared in the columns of our enterprising contemporary, the *New York Herald*. The article in question is characteristically headed: "Experiments in Barnum's Menagerie. The Wolf Weeps, the Baboon Fights,

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and the Seal Upsets the Scientists;" and purports to be the only true account of an "electriciding" expedition undertaken by a party of scientists. Barnum and Bailey's "greatest show on earth" was placed at their disposal, and thither the enthusiasts adjourned, armed with 42 Leclanchés and 100,000 ohms. The experiments began at 11 a.m., and continued until the setting of the sun. The demeanour of the various unique animals kept at this establishment when under the influence of the subtle current is there graphically described. "The seal," we are told, "didn't like it," while "the gnu, or horned horse, did not take kindly to science." The exact resistance of the oryx is, we are glad to learn, 7,010 ohms, while that of the nylghau is only 5,090. These are interesting results. The dog experiments, however, were especially valuable, as they show that electricity undoubtedly brings out any incipient hydrophobia in the canine system. One dog, our veracious chronicler tells us, "after having a moderate current passed through the base of the brain, and showing a resistance of 8,000 ohms, began to act queerly, and within half an hour showed such symptoms of hydrophobia that the keepers were compelled to kill him." The elephants, on the other hand, proved "the star attraction of the day," and actually enjoyed the sensation, and we can quite believe that "no odder sight was ever seen than an elephant, with mouth wide open, with one scientist holding a sponge on the huge tongue, and a second applying another sponge to the root of his tiny tail." After the experiments Dr. F. G. Welch, of No. 140, West Forty second-street, was heard to say, "We had too small an electric power. We should have had enough strength to have killed something," and with this bloodthirsty pronouncement the narrative closes.

West Indies and British Guiana Cable.—We learn that the cable between Punta Rassa and Kew West is now repaired.

St. George the Martyr Vestry.—At a meeting of this Vestry last week the committee's recommendation in support of the House-to-House Company's License was adopted unanimously.

Personal.—We are pleased to learn that Mr. Slater, representative of the Western and Brazilian Telegraph Company (Limited) in Brazil, has been made a Commander of the Order of the Rose.

Edinburgh.—The number of telegrams which passed through the Edinburgh General Post Office last year was approximately 4,000,000, being an increase of nearly 500,000 over the previous year.

Commission of Sewers.—At a meeting of this body on Tuesday last the report of the Streets Committee on electric lighting was again adjourned, it being resolved to take it at a special meeting of the Commission.

An Electric Lighting Contract.—The Mayor of Meaux (Seine et Marne) will receive tenders for the electric lighting of that town up to March 1. A copy of the existing agreement with the gas company will be sent to any electrical firm who asks for it. The town possesses a waterfall.

Patent Law.—Under the title of "The True Position of Patentees," Mr. H. Moy Thomas has published, through Messrs. Simpkin, Marshall and Co., a little book in which the patent laws and regulations at home, abroad, and in our colonies are explained for the information of English inventors.

Electric-Lighted Buoys.—Major Gregory and Captain Evans, of the Lighthouse Board, who lately completed an inspection of the system of lighting the buoys in Gedney's Channel, New York Harbour, by electricity, report it a complete success. It is, therefore, safe to assume that the system will be extended to other waters.

The "Gas Engineer's Annual."—This is a handsome publication of some 130 pages, containing a very complete directory of Continental, Colonial, and foreign gas companies, and a well-written series of articles on subjects of interest to gas engineers. The article on electricity we notice is a reprint of Mr. Preece's British Association address.

The Electric Sugar Fraud.—It will be some slight consolation to English shareholders in the New York Electric Sugar Refining Company to learn that all the persons implicated in the fraud, including Mrs. Friend, have been arrested in Michigan on the charge of obtaining money by false pretences. The prisoners will be taken to New York for trial.

Electricity and Snakes.—According to a German paper, electricity is being used in India to prevent the intrusion of snakes into dwellings. A couple of wires are taken round the house, which are insulated from each other and connected with an induction coil. When his snakeship attempts to crawl over these wires he receives a shock of electricity that either kills or frightens him into a hasty retreat.

Ipswich.—At the meeting of the Ipswich Town Council last week, on the recommendation of the Paving and Lighting Committee, the Council passed a resolution generally approving of the granting of the license which the Ipswich Electric Light and Power Association are about to apply for, to authorise them to construct and maintain electric lines and works, and to supply electricity within the borough.

Important Sale.—Messrs. Wheatley Kirk, Price and Goulty have issued a preliminary announcement of the approaching sale of the entire property of the Elieson Electric Company (Limited), including their British, Foreign, and Colonial patent rights, tramcar station, engines, boilers, dynamos, &c. The date of the sale will shortly be announced. Further particulars will be found in our advertisement columns.

Engraving by Electricity.—A process of engraving on glass and crystal by electricity has been communicated to the French Academy of Sciences by M. Planté. The plate to be engraved is covered with a concentrated solution of nitrate of potash and put in connection with one of the poles in the battery, and the design is traced out with a fine platinum point connected to the other pole. The results are said to be of marvellous delicacy.

Sofia.—As notified in our issue of January 18th, the Municipality of Sofia has decided to light the streets of the town by electricity. We now learn that the Ministries, consisting of 10 houses with about 20 rooms in each, will also be lit with the electric light. Tenders for that purpose will be received by the Municipality of Sofia up to the 13th April, and it is desirable that communications should be made in French or German if possible.

The Vevey-Montreux-Chillon Electric Tramway.—The following are the results of the working of this line up to the end of 1888:—Total number of passengers, 320,412; total receipts, 66,978fr. The company began operations on the 4th June with a regular service every hour in either direction. From the 12th August to the 16th September there was a 40 minutes' service commenced, and since the 17th September there has been a 20 minutes' service.

Singular Accident at Chicago.—An engineer was severely injured the other day in the engine room of a Chicago installation, owing to the sudden flying to pieces of a slate disc. An examination disclosed the fact that there was a flaw in the plate which served as an insulator between the armature and the commutator. The dynamo was speeded at 1,300 revolutions a minute, and the imperfect disc of slate parted under the centrifugal strain.

Electricity Applied to Mining.—At the twenty-second annual meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers, held at the Mason College, Birmingham, on Monday last, Mr. F. Brown read a Paper on the "The Transmission of Power by Electricity." Mr. Brown mentioned several instances of the successful application of electricity to mining both in this country and in America. An interesting discussion followed.

The South London Tramways Company and Electric Traction.—At the half-yearly meeting of the South London Tramways Company on Friday last Mr. Saunders, Q.C., asked

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whether anything was being done with a view to the ultimate adoption of electric haulage. The chairman replied that the directors were quite alive to the question of employing electricity for haulage. Some unsuccessful trials had already been made, and the question of further experiments was now being discussed.

The Indian Telegraphs.—We understand that Mr. J. H. Lane has recently been appointed Director of Traffic in the Telegraph Department, Mr. Reynolds becoming Director of Construction. Mr. Luke, who has been officiating in the latter post, proceeds to Upper Burmah to inspect the working of the telegraph lines in that new province.—The *Indian Engineer* says that it is more than probable that the heads of the Telegraph and Postal Departments will be permanently established in Calcutta.

Presentation.—An interesting ceremony took place on Monday evening, February 18, at the offices of the National Telephone Company (Limited), Leeds. The staff and men of the Leeds district testified their esteem and respect for Mr. Ralph Newburn, their late manager, by presenting him with a gold medal and a purse of gold. Mr. Newburn has been in the service of the "National" nearly nine years, and during the past four years was manager of the Leeds District. The presentation was made on behalf of the staff by Mr. J. C. Chambers, General Manager of the Yorkshire District.

The Lighting of the Houses of Parliament.—A small steam engine and dynamo, capable of supplying about 120 lamps, have been erected at the Houses of Parliament, thus increasing the total number of incandescents in the building to 620. Seventeen of the additional lights have been placed in one of the reporters' writing rooms, and the remainder are supplied to the members' entrance lobby, staircase, and corridor. After Easter the light will probably be extended to the Commons' lobby, St. Stephen's Hall, the offices immediately adjoining the House, and several of the Ministers' and reporters' rooms.

The Anglo-American Brush Electric Light Corporation.—We learn that the above company has secured an important contract for the supply of about 40 sets of combined engines and dynamos of their special design, and have now in hand orders for nearly 50 sets of apparatus of this pattern. The design has met with much favour from the European Governments since its introduction, and has been largely adopted for lighting ships of war and other vessels. The Brush Corporation have also booked a contract for the application of their system of electric traction to an important tramway line in Spain.

Leamington.—At a recent meeting of the Leamington Town Council the town clerk read the Board of Trade circular respecting underground mains, remarking that it was a rather unsatisfactory letter for the Electric Lighting Company, which it placed in the awkward position of being unable to recover any accounts. The matter was referred to the General Purposes Committee. A letter from Messrs. Chamberlain and Hookham was also read at the same meeting, offering to terminate the electric lighting contract at an earlier date than that provided for by the agreement. This matter also was referred to committee.

A Useful Improvement in Electric Light Casing.—We have recently examined an improved method of crossing electric leads, enclosed in casing, which has been devised by Mr. Bathurst. In lieu of running one wire underneath the other in an improvised groove in the base of the casing whenever a branch is taken off the main leads, Mr. Bathurst employs a semi-circular grooved block of wood, which carries the crossing wire an inch or more above the other. The crossing is covered in, and if the block is made of porcelain it forms a handy place for a fuse. This is one of those simple little devices which contribute so much towards the success of domestic installations.

Telpherage.—We learn that the United Electrical Engineering Company has secured the entire patent rights in connection with telpherage. Several important contracts are already under negotiation, amongst which may be mentioned two lines in Cornwall for the carriage respectively of 1,000 and 500 tons of tin ore per week. Under the capable and energetic management of Messrs. Manville and Madgen (the Managing Directors of the United Electrical Engineering Company) we fully anticipate that telpherage will shortly occupy a prominent position in the development of the electrical industries. No one who is capable of forming an opinion on the subject can have any doubt that it affords one of the cheapest and most efficient means of transport for heavy material which yet exists.

The India-Rubber Trade of Brazil.—Last year 15,000,000 kilogrammes of India-rubber were exported from Brazil, and this year the yield is still better, though prices rule much lower. The following are the figures for the last five years:—

Year.	Amount.	Increase.
1883-4	10,463,000 kilos.	—
1884-5	11,885,000 „	13·5 per cent.
1885-6	12,835,000 „	8 „ „
1886-7	13,395,000 „	4·5 „ „
1887-8	15,766,000 „	17·5 „ „

Of the amount exported in 1887-88 10,110,008 kilogrammes went to the United States, and 5,280,644 kilogrammes came to Europe. During the first six months of 1888 no less than 6,262,105 kilogrammes, valued at 12,924,429 reis, left the port of Belem.

Appointment of an Inspector under the Electric Lighting Acts.—At the weekly meeting of the Watch Committee of Liverpool Town Council, on the 19th inst., a recommendation was submitted from the engineer suggesting the appointment of an electrician to supervise the details in connection with the electric lighting question. The matter was discussed at some length, and eventually it was adjourned until further inquiries may be made. An opinion was expressed that the duties of the new post might be performed by an official chosen from the corporation staff, but it was explained that any person who undertook the responsibility should be thoroughly versed in the principles of electricity. At a previous meeting a resolution was passed that the city engineer communicate with Mr. Shoolbred and report further as to the appointment of an electric inspector under the provisions of the Liverpool electric lighting license.

Birmingham Electrical and Industrial Exhibition.—Following is the schedule of the electrical section:—Section No. 1: Dynamos—Motors—Alternating-Current Transformers—Accumulators—Primary Batteries—Arc and Incandescent Lamps—Insulated Cables and Wires (submarine, subterranean, and ariel)—Switch-Boards—Meters and Measuring Instruments—Automatic Apparatus—Switches—Connectors—Carbons—Electroliers—Shades and Fittings; Plant for Dwelling Houses, Ships, Theatres, Public Buildings and Central Station Installations. Section No. 2: Complete Display of Electric Lighting, upon all known systems and combinations, working in series and parallel, direct and through transformers—all Systems for Electric Transmission of Power. Section No. 3: Telegraph and Telephone Apparatus—Phonographs—Electric Bells and Clocks; Electric Welding—Electric Smelting—Electrotyping—Electro Deposition; Telpherage Working, &c., and all kinds of Electric Machinery and Appliances.

The Visit of American Electrical Engineers.—The following letter has been addressed by the Secretary of the Institution of Electrical Engineers to Mr. R. W. Pope, the Secretary of the American Institute of Electrical Engineers:—

Dear Sir: The President and Council of this Institution having been informed by Mr. W. H. Preece, one of its Past-Presidents, that many of the members of your Institute will be visiting the Paris Universal Exhibition this year, and will probably also visit London, have instructed me to inform you that it will afford them the greatest pleasure to welcome those gentlemen, and in doing all that is in their power to render their visit to England agreeable and instructive. The Council will feel obliged if you will kindly inform me how many of your members they are likely to have the pleasure of seeing, and the probable time of their arrival in London. Mr. Preece was requested to anticipate this letter by telegraphing to you "The Institution of Electrical Engineers, of London, will welcome your members and will do all it can to further the object of their visit."—I beg to remain, Dear Sir, yours most faithfully, F. H. Webb, Secretary.

Visit of the Junior Engineering Society to Deptford.—On Saturday last a party of members of this society visited the Deptford Central Station of the London Electric Supply Corporation, permission having been kindly granted by the

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directors. The party were met at the works entrance by the resident engineer, who conducted them round, and explained the many interesting and unique features of the undertaking. The huge buildings are rapidly advancing towards completion. In the engine house the smaller engines of vertical Corliss type, by Messrs. Hick, Hargreaves and Co., were seen in course of erection, and on passing to the boiler house immediately adjoining, the setting of the Babcock and Wilcox boilers was being proceeded with. An inspection of the electric installation for lighting the whole of the works, and which was started as soon after their commencement as possible, brought the visit to a close. Before the members dispersed a vote of thanks was passed, expressing the gratification which the visit had afforded them.

Barnet.—The *Journal of Gas Lighting* is responsible for the following calendar of the deplorable failure at Barnet:—Sept. 6, all lamps went out at 10:15 p.m. for some minutes; Sept. 12, the lamps were lit this night at 7:15 p.m., at 7:45 all went out, they were relit, but again went out at 8:25 p.m., and were not relit; Sept. 28, all lamps went out at 9:55 p.m., and remained so; Oct. 3, lamps not lit till 6:45 p.m.; Oct. 23, all lamps went out from 9:25 to 9:50 p.m.; Oct. 28, all lamps nearly out at 6:25 p.m.; Nov. 2, all lamps out from 5:40 to 5:50 p.m.; Nov. 4, all lamps out from 5:25 to 5:40 p.m.; Nov. 11, all lamps out from 7:25 to 7:43 p.m.; Nov. 13, all lamps out from 6:45 to 7:15 p.m.; Nov. 26, all lamps out from 6:37 to 6:45 p.m.; Dec. 1, all lamps out from 11:22 to 11:35 p.m.; Dec. 8, all lamps out from 6:35 to 9:20 p.m.; Dec. 9, all lamps out at 11:45 p.m., and remained so; Jan. 11, 1889, nearly all lamps out from 9:5 to 10:10 p.m.; Jan. 23, all lamps out till 9:5 p.m.; Jan. 28, all lamps out from 5:50 to 5:55 p.m.; Feb. 6, all lamps out from 7:10 to 10:15 p.m.; Feb. 11, all lamps out from 10 to 10:7 p.m.

The Westinghouse Converter.—Mr. R. Bellfield, of the Westinghouse Electric Company, writes from Pittsburg as follows:—"I enclose a photograph of a Westinghouse converter which has been running under very trying circumstances. You will notice it is placed under a water-pipe and entirely exposed to the weather, which during the past fortnight has been very changeable, thus causing the converter to be subjected to alternate frosts and thaws, the results of which are shown in the photograph. The converter has been running continuously day and night since it was erected, and shows no sign of being affected by its late treatment. You will notice that both primary and secondary wires, as well as the converter case, are thickly coated with ice, which shows to some extent the amount of water they have been subjected to. This is not a specially built converter for the purpose, but a standard one taken out of stock, and is not subjected to any more severe test than hundreds of its fellows stand in exposed situations every winter." The photograph enclosed with the letter shows the converter almost completely coated with ice, and with long icicles depending from it apparently some 2ft. in length.

Transition Formulæ Between the Electromagnetic and Electrostatic Systems.—In a Paper read by Mr. Blakesley before the Physical Society "On Some Facts Connected with the Systems of Scientific Units of Measurement" (to which we make further reference elsewhere in this issue), he writes:—

"I do not think a rapid answer could be given by many persons to the question, What is the value in C.-G.-S. electrostatic units of a current of, say, 33·3 practical electromagnetic units? Yet in following out the experiments of Dr. Hertz, with which Mr. Tunzelmann has made us familiar, such a calculation must, I think, be made. I will here give two formulæ, which will enable any magnitude given in one system to be brought into the other.

Let k = the exponent of l in electromagnetic system,
h = " " m " " "
n = " " l in electrostatic system,
q = " " m " " "
for any kind of magnitude brought into due correlation with others.

Then, to reduce between practical (quadrant-volt-second) units electromagnetic and C.-G.-S. units electrostatic:—

1 practical unit $= 3^{n-k}10^{10n-11q-k}$ electrostatic C.-G.-S.

To reduce between C.-G.-S. electromagnetic and C.-G.-S. electrostatic:—

1 C.-G.-S. electromagnetic unit $= 3^{n-k}10^{10(n-k)+11(k-q)}$ electrostatic C.-G.-S. units.

The 3 in these equations is meant as a sufficient approximation to the number 2·938, which is one-tenth of 'v' in quadrants per second.

I have myself not seen such reduction-formulæ elsewhere, and under the present system I think they may be found of use."

Electrical Stress.—Prof. Rücker, at the Royal Institution, on Friday evening last delivered a lecture, in which he discussed the effects of the introduction of electrified conductors into non-conducting or nearly non-conducting liquids. The subject has been studied by Faraday, Kerr, Quincke, W. Holtz, and others, but various difficulties had prevented some of the more striking phenomena being shown in experimental lectures. The lecturer and Mr. Boys last year devised a set of apparatus which made the exhibition comparatively easy. Faraday's magnetic lines of force could be shown by the aid of iron filings, but the corresponding experiment in the case of electrical lines of force in a liquid was more difficult, because the liquid was thrown into violent agitation and the solids used tended to cluster about one of the poles. These points were illustrated by experiment, and the lines of force were realised by means of powdered antimony immersed in ether. The tendency of the lines of force to become shorter and to separate the one from the other was also illustrated, and from this the fact was deduced that a body subject to electrical stress assumed temporarily a kind of crystalline structure. Kerr's and Quincke's experiments on the passage of polarised light through carbon bisulphide were then discussed. Kerr's experiments depended upon the fact that since the electrical stress was a tension along the lines of force and a pressure at right angles to them, a substance in which such a stress was produced assumed a semi-crystalline condition in the sense that its properties along and perpendicular to the lines of force were different. Light was therefore transmitted with different velocities according as the direction of vibrations coincided with or was perpendicular to these lines, and the familiar phenomena of the passage of polarised light through crystals might be imitated by an electrically-stressed liquid. These researches were exhibited with various modifications and extensions. Finally, the lecturer referred to some outstanding problems which had not yet been completely solved.

Gas v. Electricity.—The following extract from the speech of the Chairman at a recent meeting of the shareholders of the Gas Light and Coke Company will be read with interest:—"There is no doubt that the electric light is a very great comfort, and very beneficial to the public; but I say it does not compete with us, and I shall be able to give you some consoling figures in support of the assertion. I thought the best method of coming as near as we could to the value of the competition between a gas company and an electric light company was to take the part of London where there is more electric light than in any other locality—I mean the Bond-street district, where a great many shops, clubs, hotels, and public buildings are lighted by electricity. We have taken 325 of the consumers in the Bond-street district. Out of these 325 there are 29 who use the electric light. The gas-rental in 1885, when the electric light was introduced into Bond-street, was £7,527. In the year 1888, after three years' competition with the electric light in the Bond-street district, the gas rental, so far from falling, has increased to £7,836, so that, at any rate in that part of London, we have not suffered during the last three years very severely from electric lighting. Electric lighting, as I have said, is a very fine healthy child; but it is like other young children, it has troubles to come. A great many of those troubles are looming up in connection with the question of laying wires overhead and underfoot; and they will have their difficulties with the Vestries, as we have had. I do not know whether the steam-rollers will hurt them much; but there are other matters which the Vestries will find impede the use of the electric light in the streets of London. I do not think we shall hurt it; and I am sure it will not hurt us. We have taken 80 years to arrive at our position; and they will have a considerable number of years yet to exist before they will be in such a strong financial position. To compare our business with theirs is like comparing the business of a young man who has just started with that of an old gentleman who has accumulated a large fortune, and has a good going concern."

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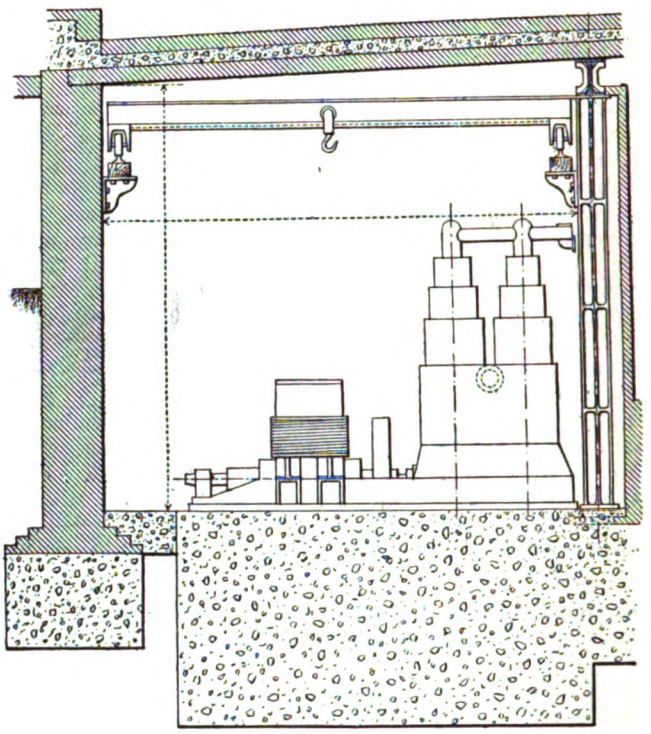
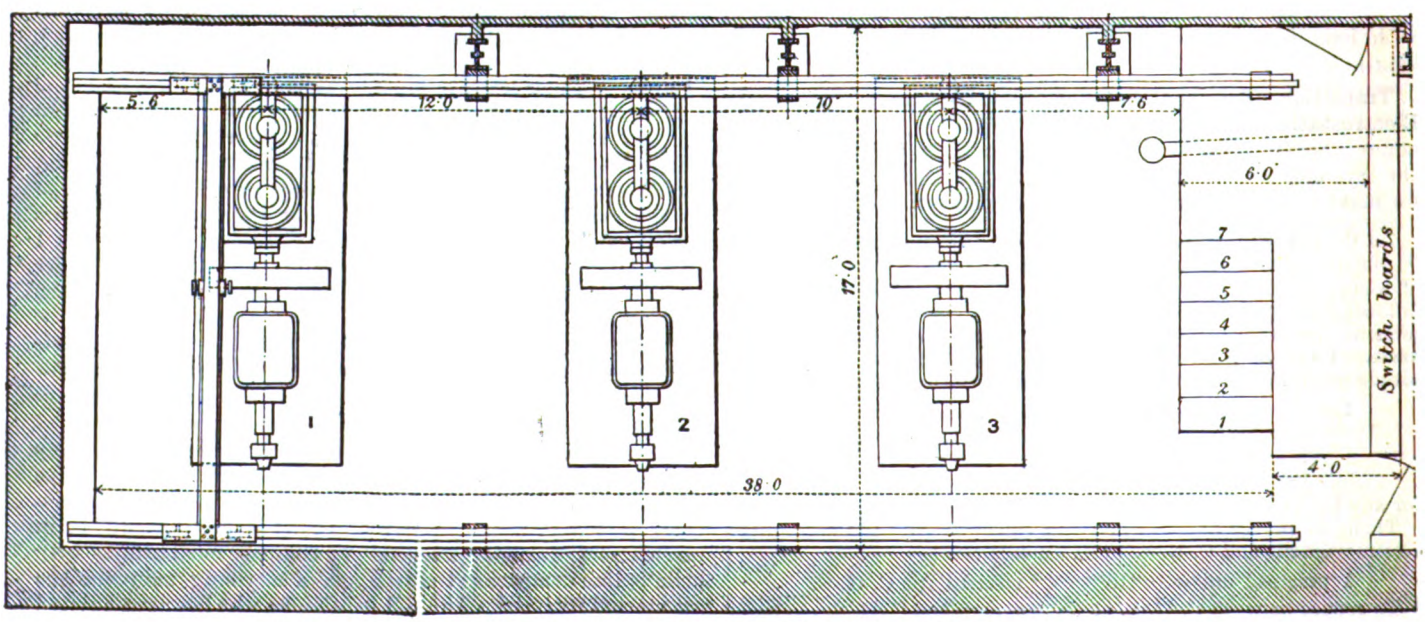
THE WHITEHALL CENTRAL STATION OF THE METROPOLITAN ELECTRIC SUPPLY COMPANY.

This station was originally undertaken in July, 1887, for the purpose of lighting Whitehall Court. It was impossible to find a site for the works, and therefore it was arranged to excavate the new road opposite Whitehall Court, and to place the machinery underground; but, as some of those in charge of the work foresaw the great development which electric lighting in the metropolis was likely to attain, a small company, known as the Whitehall Electric Supply Company, was formed to carry on the work, with all the usual powers for extension and enlargement. The success of the undertaking far exceeded the anticipations of the projectors, and the 10,000 lights which the station is capable of supplying were all taken up within a few weeks of the completion of the works. We may mention here that the standard lamp of this station is the 8 candle-power lamp run up to 10 candles. It was soon found that a far larger scheme than was at first contemplated would be necessary, and the Metropolitan Electric Supply Company was formed and took over the undertaking. The position of the works is admirably suited for the supply of current to the large clubs and hotels which form so marked a feature of the vicinity. Among the buildings lighted or about to be lighted from this station are the Grand Hotel, the Hotel Victoria, the Hotel Métropole, the Avenue Theatre, St. Martin's Church, Messrs. Hampton's large furniture warehouse in Pall-mall, and the Charing Cross Turkish Baths. In addition to these there is, of course, Whitehall Court, where, as gas is not laid on, a large demand for current may in time be expected. There can therefore scarcely be any doubt as to the future prosperity of the Whitehall Station.

The whole of the plant, comprising boilers, engines, pumps, condensers, dynamos and secondary batteries is underground, the road being carried on Lindsay's steel decking; and as the available room only amounts to 3,500 square feet, it is evident that considerable ingenuity must have been displayed in getting all this machinery into so restricted an area. The station is divided into four compartments. On the right of the entrance is the boiler-house, on the left are the pumps and condensers; passing on we come to the engines and dynamos on the right, and the battery room on the left. The dynamos are coupled direct to three fine vertical triple-expansion Willans and Robinson engines, running at 350 revolutions per minute. These engines each work up to 170 horse-power, and are run at present without electrical governors. The dynamos are by Messrs. Siemens Bros.; each of the three machines has an output of 100 kilo-watts (112 volts and 900 amperes) at 350 revolutions, and is of the latest type, with shunt-winding and drum armature. The secondary batteries, which number nearly 1,000, are of the Elwell-Parker 23L type, and are capable of giving in case of necessity 800 amperes for ten hours. The cells are arranged along the walls and down the centre of the battery room in four tiers, and as the battery room only measures 43ft. by 15ft. 6in. every available inch of space must have been made use of. The cells are connected in eight groups, each consisting of sixty in series and two in parallel. The E.M.F. at the lamp terminals is kept constant during charge and discharge by varying the number of cells in each battery, which is done by sliding switches. For charging a simple switch arrangement alters the 8 sets of 60 double cells into 10 sets of 48 double cells. Various kinds of measuring instruments are used at the Whitehall Station, the Cardew and the Schuckert voltmeters, and the Deprez-D'Arsonval galvanometers by Messrs. Nalder Bros. being preferred. The distributing mains are all laid underground down the roadways, in Callender-Webber conduits. In Northumberland-avenue, where the subway is available, all the cables are placed



Whitehall Station—Cross-section of the Engine and Dynamo Room



Whitehall Station—Plan of the Engine and Dynamo Room.

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in strong wooden boxes, buried in the base of the subway. Some difficulty was experienced in carrying out the heavy work required in the subway, as, owing to the presence of gas mains, no naked lights were allowed, and the light of the ordinary safety lamps is insufficient to work by. This was overcome by lighting the subway from end to end by electricity by means of some 20 incandescent lamps. At present all the lamps supplied from the Whitehall station are charged for at 30s. per 8 candle-power lamp per annum for continuous lighting, and 25s. for supply from nine a.m. till midnight, but eventually, no doubt, the far more satisfactory system of meterage will be adopted. The boilers, three in number, are by Messrs. Hick, Hargreaves and Co.; they work at 160lbs. pressure, and each evaporates 3,500lbs. of water per hour. Each of them is 8ft. long, with 9ft. internal diameter, the shell being $\frac{15}{16}$in. thick. Two furnaces 2ft. 8in. in diameter and 5ft. 9in. long, are fitted to each boiler. The water is taken direct from the Chelsea Company's mains and passed into a "softener." This apparatus which is supplied by the Heater and Condenser Company, is capable of softening 1,500 gallons of water per hour. The water is taken by two boiler feed pumps and passed into the heater, and thence into the boiler. In the event of any interruption to the water supply, water could be obtained from the 40,000 gallon tank at the top of the building. The main flue is of somewhat peculiar construction, so peculiar indeed that it was predicted that no draught would ever be set up in it. On leaving the boilers it bends down and takes a 12ft. drop, it then bends again and passes at a gentle inclination under the foundations of Whitehall Court to the shaft. The great height of this shaft (135ft.) has, however, proved sufficient to ensure a good draught and falsify all the predictions of failure. The exhaust steam is condensed, the hot distilled water produced being used again in the boilers, and the condensing water being used to heat the hot water coils throughout Whitehall Court, and to supply all the baths and kitchens therein.

Some idea of the complication of the work may be obtained when we note that Whitehall Court consists of 10 floors and contains 120 sets of water coils, about 102 bath rooms, and some two or three hundred hot-water taps. Here, again, many predictions of failure were made, but the system, which is now complete throughout the north block of the building, was found to work perfectly on the first trial.

In summer, when not much hot water is used, a portion of the steam escapes uncondensed. This is carried up through a 15in. iron pipe placed in the shaft, so that the clean steam is discharged at the top of the chimney without causing smoke or any nuisance whatever. The pumps at the station are used to send the water up to the domestic supply tanks at the top of the building, the pressure on the mains being insufficient for this purpose. The 18 large hydraulic lifts of Whitehall Court will also be worked from the station, so that a considerable revenue will accrue to the company from this source alone. The elevator pumps also work the sixty-five fire hydrants in Whitehall Court.

The ventilation of the underground chamber presented peculiar difficulties, as it was part of the conditions of the lease from the Crown that no opening for ventilation or otherwise should be made through the roadway or the footway. Air is admitted from an opening, 10ft. by 12ft., in the area of Whitehall Court. A pipe, 5ft. by 18in., runs along the centre of the chamber close under the roof, and into this opening a number of 6in. pipes of various lengths are laid close to the roof in the channels of the Lindsay decking. The end of the square pipe communicates with the chimney, and a very good draft is obtained without interfering with the boiler draft. Although this draft works admirably in the present season, yet in preparation for the approaching summer, it has been thought wise to put in a small Sturtevant blower, driven direct by a small Willans engine, which is now being erected. This will be placed in the air inlet for the purpose of increasing the quantity of air in circulation. One noticeable feature of this installation is the perfect silence of the machinery. Standing, for instance, in the battery room, it is impossible to tell whether the engines are running or not. Nothing but a little clean steam is ever visible from the chimney.

Although neither the station arrangements nor the method of distribution present any great novelty, yet the admirable manner in which the many difficulties connected with an underground situation and so restricted a space have been overcome reflects the greatest credit on Mr. J. E. H. Gordon, who, with the able assistance of Mr. Frank Bailey, designed and carried out the whole of the work, including even the architectural drawings for the station.

The Metropolitan Company have now on order for London plant for 9,300 horse-power, capable of supplying over 200,000 lights. This is distributed between six stations, and the works are all being pushed on day and night with the utmost vigour, and it is expected that the whole of this instalment of lamps will be at work in the course of the next summer.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

"On Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits."*

BY A. E. KENNELLY.

Since the earliest days of commercial telegraphy—the days that first reaped the labours of Sœmmering and Steinheil, Gauss and Weber, Cooke and Wheatstone—the substance of our planet has been impressed into such universal conducting duty that now scarcely a circuit closes, be it across an ocean or be it across a meadow, but embraces its share of the earth in its completion; and the task thus imposed is generally borne so readily and executed so perfectly that, until the existence of the eaves-dropping telephone, it was really doubted whether in truth the earth could or did conduct the current entrusted to its care.

Considering, then, the great obligations telegraphy owes to the earth—that the existence of some hundred thousand miles of metallic conductor at present in daily telegraphic operation implies in a certain sense the corresponding twin existence of an equal length of terrestrial conductor ready made by nature; that it has even been possible to telegraph over a space of which the metallic conductor formed but a very proper fraction—the cases that are met with where the earth fails to fulfil its part excite astonishment more by their rarity than by the force of those laws whose mandates they obey.

Almost all such cases of imperfect earth are, we know, traceable to some fault either in the earth connection itself or in its immediate neighbourhood; and a remedy is found by adequately increasing the surface area of the buried electrode, or the conductivity of the ground in its vicinity; so that they are not really failures of the earth's conduction, but failures in securing the necessary degree of connection with the earth's mass.

There are, however, other cases, brought about by conditions more deeply seated and more rarely met with, which will occupy our present attention.

A Paper by Mr. James Graves, "On Vibrations due to Earth Plates," was read before this institution in January, 1875, and it will be seen that the phenomena therein described are probably related to those that will be presently detailed. Although the matter has not occupied the institution's direct attention since that date, no doubt some of its members will have independently observed similar phenomena, and can bring forward such additional evidence as cannot fail to elucidate a subject at once replete with technical interest and important practical bearings.

These phenomena are presented by the Atlantic cables of the Direct United States Cable Company, with whose permission the facts are laid before the institution.

The two cables of this company, terminating in Nova Scotia, run to Ireland and to Rye Beach respectively. Their landing place was originally Torbay, N.S., but they were removed thence to Halifax some eighteen months since.

The diagram (Fig. A) supplies the outlines and main features of Halifax Harbour. The Irish cable was first brought into the cable-house, situated 40 feet above high-water mark, upon the beach opposite George Island, on the 23rd October, 1887, and it was put in communication with the town office by means of a line cable and a return earth cable, side by side, in an iron pipe. Each cable was 0·7 knot long, had a resistance of 8·3 ω, a capacity of 0·25 ϕ, and a high insulation. The line cable united with the Irish shore end through lightning guards, while the earth cable made good soldered connection with the shore end sheathing.

Some vibration of the mirror spot, due to electrical disturbance, was noticed on first joining up the circuit at the office through instrument and condensers, but this was at the time attributed to faults which then existed in the cable. Beyond this continual

* Paper read before the Institution of Electrical Engineers on 14th February, 1889.

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vibration, no noteworthy feature occurred until six days later (29th October), when the Rye Beach cable was landed at the same cable-house, and joined up with the office by a precisely similar pair of cables running through iron piping in the same trench with the other above mentioned. This cable is worked on a double-current Morse system without condensers, and it was immediately noticed that sending to Rye Beach with 12 volts of battery power visibly disturbed the mirror spot on the Irish circuit, although each cable made earth separately through its own sheathing *viâ* the insulated return cables to the beach. Receiving from Rye Beach did not disturb the mirror, nor did the operation of the Irish cable in its turn affect the less delicate apparatus of the Morse circuit.

The only remedy that could be, or has since been, practically available without adding to the retardation of the circuits, was the reduction of the Morse battery power on one hand, and the sensitiveness of the Irish mirror on the other, as far as the operation of the circuits would conveniently permit.

After the removal of the faults in the Irish cable the vibrations of the mirror still continued, and it was noticed that not only these, but periods of disturbance coincident with local meteorological changes, affected the signals more than had been on record with the same circuit when worked previously from Torbay. On this was

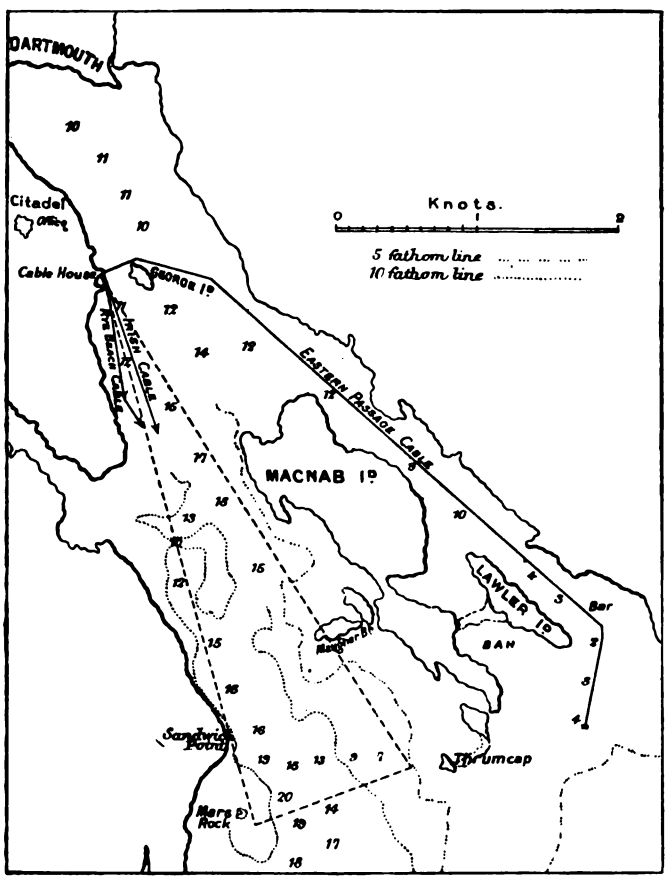

FIG. A.—Map of Halifax Harbour.

superposed the interference caused by transmission on the Rye Beach circuit, and the combined disturbance at times made the mirror signals difficult to read.

The Rye Beach shore end was at first laid very near to the Irish cable, and actually over it at one or two points. The cables were, however, subsequently separated, although they still necessarily lie at different points in close proximity. This separation of the cables was found to have sensibly lessened their interference.

The operation of the cables from the cable-house instead of from the office was found to produce no change in the nature or degree of disturbance, while experiment failed to produce any visible interference between the trenched cable circuits from office to Beach, even on the most delicate instruments.

A third cable was then laid from the cable house across the harbour, and out through the eastern passage in the direction shown on the diagram. It had a total length of 5·8 knots, sheathed up to within half a mile of the sea end. This unsheathed half-mile of core terminated in a copper earth-plate one yard square, nearly on a line between Thrumcap Rock and Hartland Point. This well-insulated line offered every prospect of securing a good and independent earth by its large terminal plate. When, however, it was joined up at the cable house with the Irish circuit, in the place of the Irish shore end sheathing, the interference from the Rye Beach transmission remained as marked as ever.

To determine the nature of this obstinate interference a series of experiments was made at the cable house as follows :—

All existing connections were for the time dismantled, and only the two cables, the two earth-wires soldered to their respective sheathings, and the core of the third cable, or six-mile earth, were brought up to the testing table.

The resistances between these three earth-wire terminals was measured as follows by bridge :—

Between Irish sheathing and Rye Beach sheathing 0·16 ω } all
,, ,, ,, ,, six-mile earth.....65·7 ω } steady.
,, Rye Beach ,, ,, ,, ...65·7 ω }

From which the resistance of each sheathing earth connection would, of course, be 0·8 ω, and of the six-mile earth 65 6 ω.

The only apparatus then retained for investigation was a Daniell battery of fourteen gravity cells—used with, and sometimes also without, a pole-changer—for exciting disturbance, and a sensitive speaking mirror—used with, and also without, condensers of 40 ϕ capacity—to render any interference visible.

Experiment 1. (*See* Fig. 1.)—Sending reversals from seven cells into the Rye Beach cable produced vibrations of the spot on the mirror instrument in circuit with the Irish cable, its sheathing, and 40 ϕ.

Experiment 2.—Similarly, sending reversals into the Irish cable, using its sheathing, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and sheathing. (Fig. 2 is identical with Fig. 1, reversing the connection of the two cables.)

Experiment 3. (*See* Fig. 3.)—Sending reversals into the Rye Beach cable produced vibrations on the mirror in circuit with the Irish cable condenser and six-mile earth.

Experiment 4. (*See* Fig. 4.)—Sending reversals into the Rye Beach cable, using six-mile earth, produced vibrations on the mirror in circuit with the Irish cable condenser and its own sheathing.

Experiment 5.—Sending reversals into the Irish cable, using the six-mile earth, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and its own sheating. (Fig. 5 is identical with Fig. 4, reversing the connection of the two cables.)

Experiment 6.—Sending reversals into the Irish cable, using its own sheathing, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and six-mile earth. (Fig. 6 is identical with Fig. 3, reversing the connection of the two cables.)

Experiment 7. (*See* Fig. 7).—Sending reversals on the circuit formed by the six-mile earth, battery, and Rye Beach sheathing, the disturbance on the mirror in circuit with the Irish cable condenser and sheathing was more decided than in any of the preceding experiments.

Experiment 8.—Similarly, sending reversals on the circuit formed by the six-mile earth, battery, and Irish cable sheathing, the disturbance on the mirror in circuit with the Rye Beach cable condenser and sheathing was equally great. (Fig. 8 is identical with Fig. 7, reversing the connection of the two cables.)

Experiment 9.—The last two experiments were repeated with the condenser removed and the mirror in direct circuit between cable and sheathing. The continual vibration of the spot made observation difficult; but during periods of comparative quiescence it was soon determined that the disturbance produced by depressing one of the keys was not of a momentary nature only, but consisted of a small deflection, permanent during the whole period of key application, and of direction depending upon the key selected. It was also ascertained that this deflection was not due to any local electromagnetic action by

Experiment 10. (*See* Fig. 9.)—On sending reversals between the two cable sheathings in circuit with the battery, no disturbance could be detected on the mirror in circuit with one of the cables and the six-mile earth.

This small steady deflection produced by holding down the key in either of the two cases tried in Experiment 9 was more plainly visible when the mirror was in circuit with the Rye Beach cable, which, besides its shorter length, had no condenser in circuit at the distant station. To obtain some quantitative information regarding the strength of current represented, the fourteen cells were connected in series and more careful observations made.

Experiment 11. (*See* Fig 10.)—Closing the circuit formed by the fourteen cells, the six-mile earth, and Irish sheathing, measurements were made of the steady deflection so produced on the mirror joined up with the Rye Beach cable and sheathing.

The deflection obtained was subsequently found to approximately represent the two-hundred-thousandth part of an ampere—*i.e.*, 5 micro-amperes—and its direction was observed to be that indicating a current entering the Rye Beach cable from that pole of the battery which was connected to the Irish sheathing, reversing when the battery was reversed. Thus, in the figure the copper pole of the battery being shown connected to the sheathing, the deflection represented a current from the copper pole entering the Rye Beach cable through the mirror.

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DIAGRAMS ILLUSTRATING MR. KENNELLY'S PAPER.

Fig 1.
Experiment Nº1.

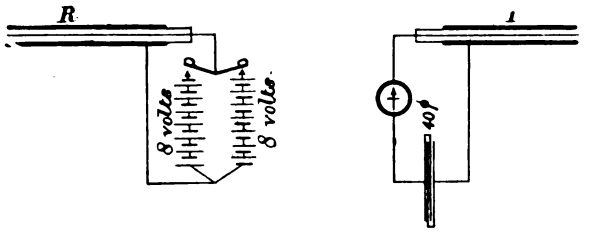


Fig 3.
Experiment Nº 3.

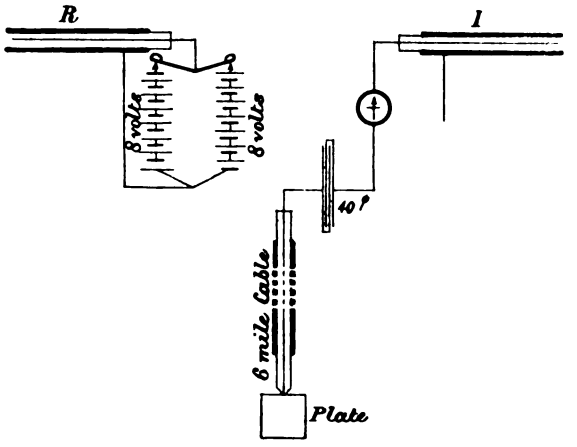


Fig 4.
Experiment Nº 4.

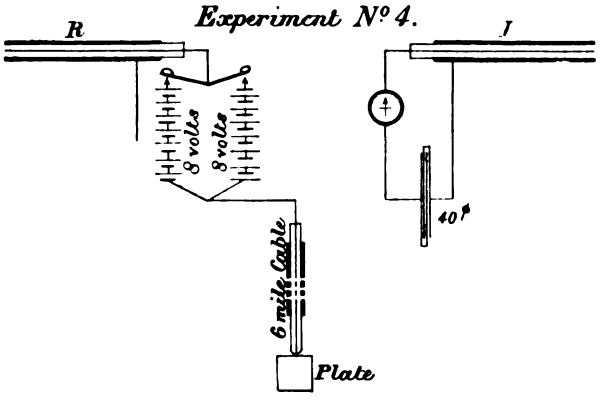


Fig 7.
Experiment Nº 7.

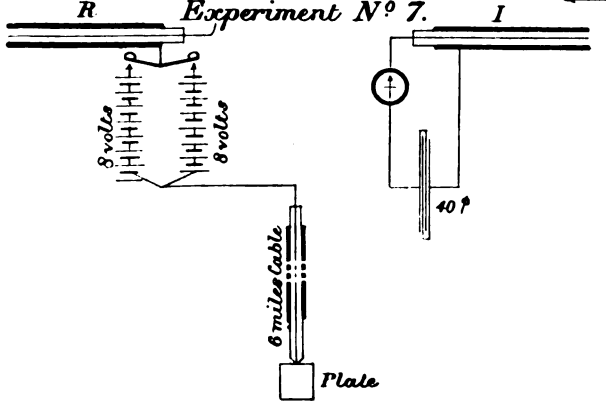


Fig 9.
Experiment Nº 10.

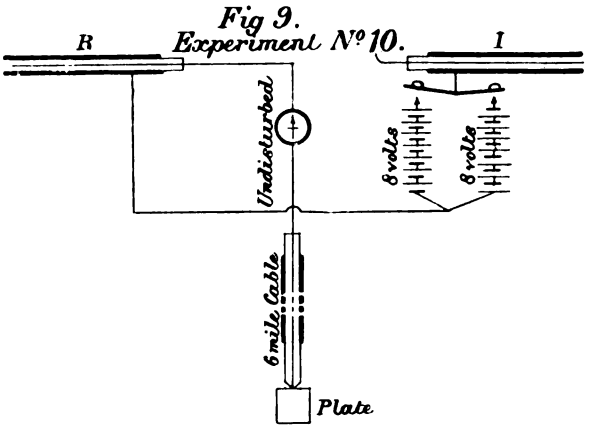


Fig 10.
Experiment Nº 11.

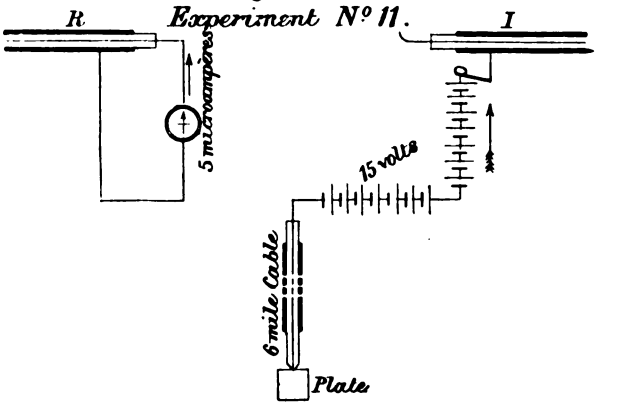


Fig 11.
Experiment Nº 12.

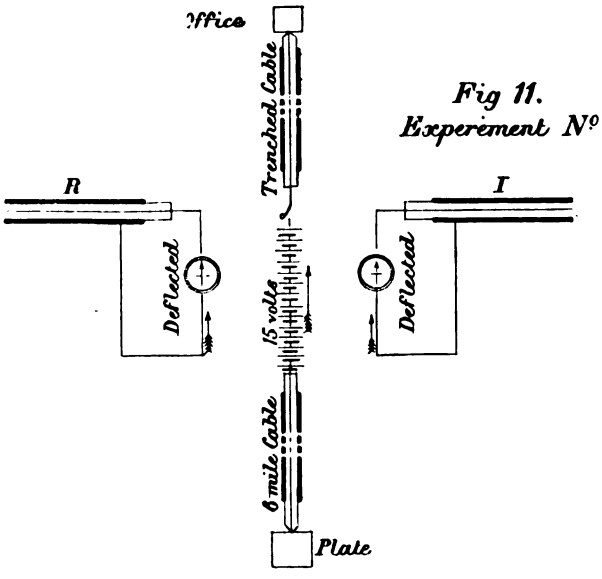
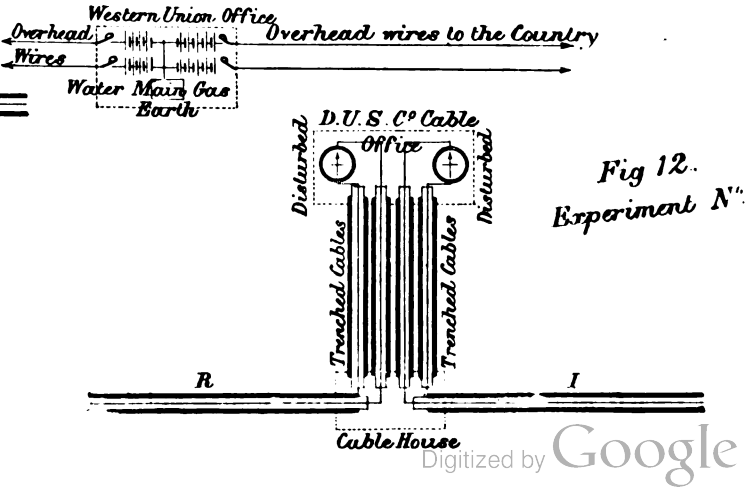


Fig 12.
Experiment Nº 14.



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Experiment 12. (*See* Fig. 11.)—The Irish sheathing was replaced in the battery circuit by the water-pipe earth connection at the office through the trenched cable. On depressing the key the mirror showed the same permanent degree of disturbance as before in each cable circuit.

Experiment 13.—This experiment was a repetition of No. 3, with the condenser removed. It was subsequently observed in this case that the disturbance was not permanent during the depression of the battery key, but consisted of a small vibration of the spot at the opening and the closing of the battery circuit.

Experiment 14. (*See* Fig. 12.)—This was carried out at the office, situated in the principal street of the town, and nearly opposite to the Western Union Telegraph Office, fifty yards distant. All the Western Union wires are overhead, and the earth connections made for them are the gas and water mains, which, with the telephone lines, form the only metallic connection between the two buildings. With the courteous assistance of the Western Union officials it was arranged that at a given word by telephone several of their circuits should suddenly be operated, and again, all stopped.

When this was done the effect was distinctly visible upon a mirror in circuit with each cable, the disturbance being greater on the Rye Beach line, the earth connections being the cable sheathings through the insulated cables in the trench. Only four known causes could under any conditions produce interference between the two cable circuits, these being, of course, electrostatic induction, electro-magnetic induction, leakage, or bad earth connection in common; and, in the absence of evidence, any one or more might produce it, although no reason could be demanded for the operation of any, since cables lie in other parts of the world for greater distances at equal proximity without the least visible interference.

Experiment No. 10, together with the preliminary trials with the trenched cables, showed that the causes were not to be traced locally to these or to the apparatus; and the high insulation of the cables and circuits, together with the fact that the tests were carried out at the cable house, precluded all possibility of leakage being concerned, so that the operating causes were thus limited to the two forms of induction and bad earth.

The first six experiments did not directly point in favour of any particular cause, but Nos. 7 and 8 rendered the possibility of electro-magnetic disturbance untenable, since the exciting circuit, except in the cable sheathing itself, took a course, as seen on the map, almost at right angles to the two main cables. They further showed that the interference was such as a deficient earth connection would produce. Experiment No. 9 confirmed this view, since no form of induction could set up the steady deflections observed; and leakage being out of the question, bad earth was the only cause that could produce them. It was further necessary to suppose that not only one but both cable sheathings failed to secure good earth, and that the resistance in their respective earth connections was common to both.

Experiment 11 corroborated this position; and No. 12 did more, for it extended the limits of this bad earth region over the whole water-pipe area of Halifax, as it would have been impossible to obtain interference under those conditions unless the cable sheathings and the town water pipes formed a common conducting system throughout whose limits imperfect earth connection existed. Finally, the evidence of Experiment 14 followed the same direction, the exciting circuit being in this case the Western Union land lines.

The imputation of bad earth to the gas and water-pipe area of a town, and that town a seaport, is sufficiently remarkable, but the presumption of a general earth imperfection in a system of extended water and gas mains, together with the sheathings of three cables running directly into an arm of the sea, may at first sight appear an outrage upon credulity. Due consideration of the experimental evidence renders the conclusion, however, inevitable, and this is tantamount to the assertion that the whole of this system—that is to say, all the land covered by the town, as well as that forming the harbour basin—is composed of substance more or less insulated or insulating.

(To be continued.)

REVIEWS.

The Life of Sir William Siemens, F.R.S., D.C.L., L.L.D., &c. By William Pole, F.R.S. (Hon. Sec. of the Inst. Civ. Eng.) London: John Murray, 1888.

In the character of Sir William Siemens there were combined to an unusual degree very many of those conspicuous qualities for which the present century is chiefly distinguished, and, we may add—although Sir William was not himself of English birth—those qualities which have above all distinguished the English race. His engineering talent was of the very highest order, and he never shrank from grappling with problems of the first degree of magnitude and complexity in his own especial field. The pioneering work which he accomplished in Submarine Telegraphy, and in particular his designs for the "Faraday" cable ship, would alone have won for him a noteworthy place in the annals of engineering. As a man of science his knowledge was sound without being abstruse, and his investigations were chiefly directed towards practical utilitarian results. As an inventor his work is characterised by such originality, fertility of resource, and breadth of range, as it would be difficult to parallel. Unlike some modern "inventors," whose merit largely consists in their ability to attempt every conceivable combination for effecting the object in view, until by a process of exhaustion the most suitable device is arrived at, the inventive capacity of Sir William Siemens was directed and controlled by a clear conception of the conditions of the problem before him, and of the resources at his disposal for its attack. He was able, first, to fall back upon broad general principles, and then his keen practical instinct seemed to guide him almost unerringly to the details of their application.

Either singly, or in conjunction with others (chiefly his brother Werner), he secured no less than 113 patents in this country. They range over a vast field, and include steam engines, hot air engines, gas engines, water engines, cooling and freezing, evaporation and distillation, river engineering, the iron and steel manufacture, and other branches of metallurgy, gunnery, measuring apparatus, pneumatic tubes, glass making, armour-plating, telegraphs, electric lighting, electric power, and electric apparatus generally, in great variety, gas lighting, railway appurtenances, explosive compounds, and other miscellaneous matters.

As a man of business, his promptitude, energy, and capacity for work, were little short of marvellous. Combining, as he did, during many years of his life, the profession of a civil engineer with the occupations of a manufacturer and contractor on the largest scale, and in such diverse directions as that of telegraphy and iron smelting, he was yet able, by systematic attention to each in turn, to get through a vast amount of work of the most multifarious kind. In his later years the numerous scientific and other societies in which he held a prominent position made no small demand on his time, and he was a constant attendant at their meetings. The numerous Papers which he read before the British Association, the Royal Institution, the Royal Society, the Institution of Civil Engineers, the Telegraph Engineers (of which he was the first President, and, *de facto*, the Founder), and elsewhere, are marked by very considerable literary ability; indeed, they furnish admirable examples of the pure and lucid style in which scientific Papers *ought* (though unfortunately they are not) always to be prepared. This is the more noteworthy considering that English was to him an acquired language.

A life so full of enterprise and activity, and so intimately concerned with those great departments of human labour by which material civilisation is advanced, could scarcely fail to furnish matter for a story of the highest interest. But at the same time we are bound to recognise that the task of the Biographer now under review has been one of no small difficulty. To compress within the limits of some four hundred pages an adequate account both of the personal career and of the labours of Sir William Siemens could only have been accomplished by the sacrifice of a vast amount of available material. On the whole it would seem that the selection has been a judicious one, although it is possible that one class of readers may regret that a greater space is not afforded for personal detail, whilst another class would have preferred to learn more fully the particulars of his scientific achievements. In style, Mr. Pole's memoir is written with simplicity and straightforwardness, and, as need scarcely, perhaps, be said, with adequate knowledge of the *technique* of the scientific and engineering profession. Seeing, however, that a further opportunity of touching upon the scientific aspect of Sir William Siemens' career will shortly be afforded by the publication of his collected papers (now in the press), we shall confine ourselves, in the space still at our disposal, to a brief reference to some of the leading events of his life as recorded in the biography before us.

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William Siemens was born near Hanover in 1823, his father belonging to the yeoman class of farmers. The children were ten in number, eight sons (of whom William was the fourth) and two daughters. At the age of fifteen his parents would have placed him in a mercantile house in Cologne, but Werner, who was seven years his senior, persuaded his father to allow him to take charge of his brother's future career, with a view to his training as an engineer. Under this arrangement William commenced the systematic study of the physical sciences, first at Lübeck, afterwards at Magdeburg, and finally at Göttingen University, and as he had already received a sound general education, he rapidly became proficient in mathematics, mechanical drawing, and mechanical and physical science as then taught. At this period the letters which passed between the two brothers, many of which are preserved in the biography, are full of interest, and testify to the affection which existed between them, and which only strengthened as years advanced. On leaving Göttingen William entered as a pupil the engineering factory of Count Stolberg, at Magdeburg, where he remained two years, carrying away with him a certificate which stated that he had been "industrious, trustworthy, and well-behaved," and had acquired "considerable facility in machine drawing." Meanwhile, at the suggestion of his brother Werner, in his spare time he had been making experiments on the deposition of gold and silver by electricity, and with so much success as to lead his brother, as well as himself, to believe that money might be made by the sale of the patent rights of the process which he had elaborated. England was considered to afford the most promising field for the enterprise, and at the age of twenty, in March, 1843, William Siemens arrived in London with a very limited supply of funds, and a vague idea that the British Government would examine the invention, and would reward him according to its merits. His knowledge of English at this period was by no means perfect, and the morning after his arrival he entered a shop in Finsbury-pavement under the impression that the word "Undertaker" over the doorway betokened the office of a functionary such as he was in search of. Once inside he was not long in discovering the mistake. Fortunately, however, he speedily fell into good hands, and left London for Birmingham with a letter of introduction to the already famous firm of Elkington Brothers. We have only space to add that when he left England a few weeks later the youthful inventor carried with him no less than £1,500, for which sum the Elkingtons had acquired his process. On his return his brothers and sisters hailed him as a veritable Croesus. A year later he was again in this country with an invention which he called the Chronometric Governor, upon which he set the modest valuation of £36,000. The easy triumph of the previous year was not, however, destined to be repeated, and a very long period elapsed before the chronometric governor—ingenious as it is—became anything like a financial success. Another invention of his earlier years, Anastatic Printing, was even less successful; both these projects cost Siemens many hours of anxiety, and for a time seriously handicapped his financial progress. More than once he seems to have almost lost heart, and at one period he even thought seriously of betaking himself to the California gold diggings. Fortunately the wise counsel and co-operation of Werner prevented the realisation of this rash idea. Meanwhile Werner himself had perceived something of the importance which the science of Telegraphy was destined to attain, and at the end of 1884 we find him writing to his brother:—

"I am now resolved to establish for myself a fixed career in telegraphy. This will become a special and important branch of scientific engineering, and I feel that I have a call to take up its organisation, as it is, I am convinced, yet in its infancy."

By the end of the following year the firm of Siemens and Halske had made a modest commencement—how modest may be gathered from the fact that the workshop occupied only one story of a building in which both the partners lived; but the inventive talent and scientific knowledge of Siemens, together with the mechanical skill of Halske, and the industry and integrity of both, from the first ensured success. It was in this factory that gutta-percha was first applied as the insulating covering of electric wires. In 1851 much larger premises were secured, and from that time forward their career was one of almost uninterrupted prosperity. Meanwhile William Siemens had undertaken to represent the firm in London; he had read a Paper on "Telegraphs" at the Society of Arts in 1851, and had arranged a large display of telegraph material at the Great International Exhibition of the same year. About the same time he became a partner in the Berlin firm, and the English branch was soon after established.

It is not our intention, even did space permit, to follow in detail the remainder of Sir William Siemens' career. From this time onward his attention was almost unremittingly devoted to the applications of electricity, and with what degree of success very few of our readers can need to be told. The volume is one which might be read with profit by every student of engineering science, for with the exception of his very earliest triumph—which was in part perhaps a happy turn of Fortune's wheel—it is plain to see that Sir William, and his brothers also, won their splendid successes by dint of sheer hard work, by undaunted perseverance, by continued attention to the lessons of experience, and by the exercise of a high sense of integrity, at least as much as by reason of exceptional intellectual ability.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, February 22nd.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Some Considerations in favour of Gas-producing Furnaces in preference to other types." By T. A. GUYATT, Stud.Inst.C.E.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Concert at the St. James's Hall Restaurant. Ladies Night.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "In the Heart of Atlas." By HAROLD CRICHTON-BROWNE, F.R.G.S.

SATURDAY, February 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

PHYSICAL SOCIETY.

3 p.m. Note on "The Measurement of Electrical Resistance." By Dr. J. W. WAGHORN. Notes on (i.) "A New Polarimeter;" (ii.) "The Formation of a Cross in certain Crystal Structures." By Prof. S. P. THOMPSON, D.Sc. Note on "Electrical Measurement." By Prof. AYRTON, F.R.S., and Prof. PERRY, F.R.S.

SATURDAY LECTURE SOCIETY.

3 p.m. Lecture in the Lecture Theatre of the South Kensington Museum. "Hypothesis of the Meteoric Origin of the Heavenly Bodies and the Earth." By Prof. J. NORMAN LOCKYER, F.R.S.

CITY AND GUILDS OF LONDON INSTITUTE OLD STUDENTS' ASSOCIATION.

7:30 p.m. Smoking Concert at the Manchester Hotel.

TUESDAY, February 26th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "Alternate-Current Machinery." By GISBERT KAPP, A.M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Applied Art Section. "English Bookbinding in the Reign of Henry VIII." By W. H. J. WEALE.

WEDNESDAY, February 27th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Irish Lace Industry." By ALAN S. COLE.

THURSDAY, February 28th.

ROYAL INSTITUTION.

8 p.m. Afternoon Lecture, "The Venom of Serpents and their Allied Poisons." By SIDNEY MARTIN, M.D., B.Sc.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion "On Certain Phenomena connected with Imperfect Earth in Telegraph Circuits." By A. E. KENNELLY (Associate). "Some Electric Lighting Stations and their Lessons." By Prof. GEORGE FORBES (Member).

FRIDAY, March 1st.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Leigh Hunt." By EDMUND GOSSE, M.A.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 447
The Whitehall Central Station of the Metropolitan Electric Supply Company. Illus. 452
The Institution of Electrical Engineers. — "On Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits." By A. E. Kennelley. Illustrated 453
Reviews 456
Meetings of Scientific Societies. 457
The Edison Lamp Patents 458
Dr. Armstrong on Some Fundamental Points in the Theory of Electrolysis 459
Legal Intelligence—
Edison and Swan Electric Light Company *v.* Holland and Others 461
The London Electric Supply Corporation (Limited) *v.* Roberts, jun. 465
American Notes 465
Notes from Paris 466
Notes from Brussels 466
Notes from Vienna 467
Correspondence—
Testing Insulation Resistance.—Andrew Jamieson... 467
"Practical Electrical Measurement."—Sydney Evershed 468
The Effects or Currents upon Conductors; and the "Mœnnich Indicator."—Charles H. Yeaman 468
Hempen-Covered Cables.—W. R. Lugar 468
Books Received 468
Patent Record 469
Companies' Meetings, &c.—
Submarine Telegraph Company (Limited) 470
Telegraph Construction and Maintenance Co. (Limited) 470
The Brighton and Hove Electric Light Co. (Limited) ... 470
New Companies Registered ... 471
City Notes, &c. 471
Companies' Share List 472

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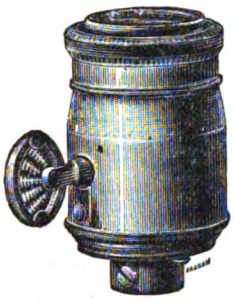
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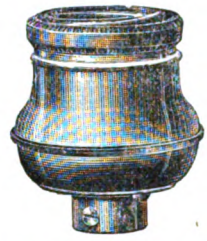
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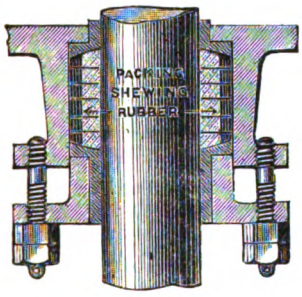

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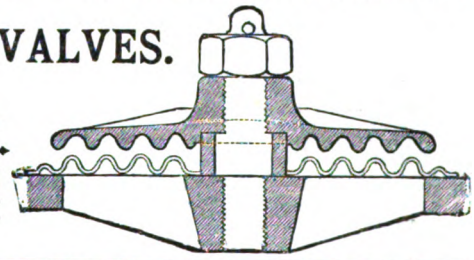

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Advertisers in "The Electrician" have their names inserted under the following headings in this Index FREE OF CHARGE.

ACCUMULATORS. PAGE.
Drake and Gorham ..... —
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8

ALTERNATORS.
Anglo-American Brush Co..... 17

AMMETERS.
Nalder Bros. and Co. 9
Sharp and Kent ..... —

ANCHOR & SHIPS' SMITHS.
Moore (W. and E.) 20

ANTI-FOULING COMPOSITIONS.
Kirkaldy (J.) and Son 20

ASBESTOLINE.
Bell's Asbestos Company 22, 23

AUCTIONEERS AND VALUERS (Mechanical).
Wheatley Kirk, Price and Goulty 3

BATTERIES.
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 9
Latimer Clark, Muirhead & Co. 1

BATTERY JARS.
Joseph Bourne and Sons 2
Cannington, Shaw and Co..... 13
Gent and Co. ..... —
Price, Sons and Co. ..... —
South Yorkshire Bottle Co. 2
J. Stiff and Sons 15

BELTING.
Balderston and Co. ..... —
Moseley and Sons..... —
Thompson and Rew ..... —

CABLE COMPANIES.
Anglo-American Telegraph Co. 25
Direct United States Co..... 25
Eastern Telegraph Co..... 26
Eastern Extension Telegraph Co. 26
Indo-European Co. 24

CABLE SUPPLIES.
Latimer Clark, Muirhead & Co... 1
Elliott Brothers 17
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
R. Johnson and Nephew..... —
Johnson and Phillips 1
Pirelli and Co. 9
Telegraph Manufacturing Co. .. 10
M. Theiler and Sons 3

CARBONS.
Anglo-American Brush Co. 17
Barnsley Carbon Co..... 15
Belfast Electric Appliances Co.. 20
General Electric Co. 13
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 9
C. A. Müller 16
Thompson and Rew (Carré) .... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 13

CASINGS.
McGaw and Co. 15

CUT-OUTS.
Electric Apparatus Co. 2
General Electric Co. 13
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 13

CYCLOSTYLE.
Facsimile Apparatus Co..... 24

DISINFECTANTS.
Sanitas Co..... 16

DYNAMO MANUFACTURERS.
Allen and Co. ..... —
Anglo-American Brush Co. 17
Blakey, Emmott and Co. 2
Clarke, Chapman, Parsons & Co. 6
Latimer Clark, Muirhead & Co.. 1
Crompton and Co. (Limited).... 12
Edison & Swan United Electric Light Co. 5
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
Gülcher (New) Electric Light and Power Co..... 16
W. T. Henley's Teleg. Works Co. 1
M. Immisch..... 18
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 9
Laurence, Paris and Scott (Ltd.) 18
Paterson and Cooper 2
Sharp and Kent..... —
Statter and Co. 2
Telegraph Manufacturing Co. .. 10
Thompson and Rew ..... —
United Electrical Engineering Co. —
Western Electric Co. 18

EBONITE & VULCANITE.
Harburg India Rubber Co. ..... —
D. Moseley and Sons ..... —

ELECTRIC BELLS.
General Electric Co. 13
Gent and Co. ..... —
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —

ELECTRIC BELLS—(*cont.*). PAGE.
London Electric Wire Co. 2
Telegraph Manufacturing Co. .. 10
Julius Sax 2
Western Electric Co. 18
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 13

EDUCATIONAL.
School of Electrical Engineering —

ELECTRIC LIGHT.
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co..... 2
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 6
Crompton and Co. (Limited).... 12
Drake and Gorham..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
Gülcher (New) Electric Light and Power Co..... 16
W. T. Henley's Teleg. Works Co. 1
House to House Electric Light Supply Company 4
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down (Thomson-Houston) 2, 9
Paterson and Cooper 2
Schmidt-Douglas Electric Co. .. —
Statter and Co. 2
United Electrical Engineering Co. —
Woodhouse and Rawson (Ltd.).. 13

ELECTRICAL & INDUSTRIAL EXHIBITION 11

ENGINEERS & CONTRACTORS
Allgemeine Elektricitäts-Gesellschaft, Berlin 3
Allpress and Belshaw 13
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co.... 2
Booth, Ellson and Co. 11
Latimer Clark, Muirhead & Co. 1
Chamberlain and Hookham 9
Clarke, Chapman, Parsons & Co. 6
Crompton and Co. (Limited).... 12
Drake and Gorham ..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down 2, 9
Laurence, Paris and Scott (Ltd.) 18
Nalder Bros. and Co. 9
Paterson and Cooper 2
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Sharp and Kent..... —
J. S. Starnes and Sons 8
Telegraph Manufacturing Co. .. 10
M. Theiler and Sons 3
Thompson and Rew..... —
United Electrical Engineering Co. —
Verity (B.) and Sons 7
Woodhouse and Rawson (Ltd.).. 13

ENGINE PACKING.
Beldam Packing and Rubber Co. 13
Bell's Asbestos Company 22, 23
J. S. Starnes and Sons..... 8

ENGINES.
Bumsted, F. D. 17
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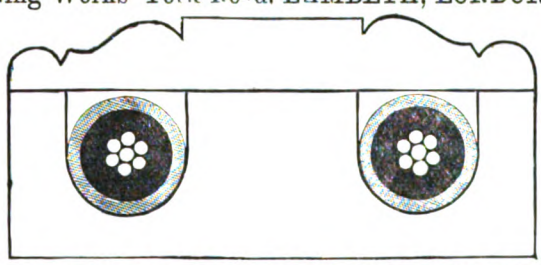

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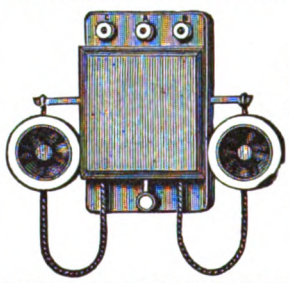

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no one could have made the carbons he describes without considerable previous experiment; fourthly, because one of the processes described, namely, mixing the carbons with volatile powder, I believe to be practically injurious if done as Edison directs; fifthly, because the coating with a non-conducting, non-carbonising substance, if not injurious, is of no practical utility; sixthly, because the same may be said of coiling the filaments, on which the patentee lays great stress."

These several grounds for Mr. Justice KAY's decision were the more noteworthy because a similar suit had been instituted against the firm of Woodhouse, Rawson and Co. in 1886, when the Edison patent was upheld both in the Courts below and in the Appeal Court. Mr. Justice KAY was led to set aside the decisions previously delivered as having been obtained on insufficient evidence, the fresh facts brought before him seeming to justify that conclusion.

In view of the case being taken to a still higher tribunal, it may be worth while to examine the grounds on which chiefly the Appeal Court has reversed the decision of the Court below. These grounds are not so much scientific as legal—that is to say, on the main points Mr. Justice KAY, whether correct or not in his interpretation of the scientific evidence, was wrong in point of law. For example, Lord Justice COTTON maintains that "a patent is not to be defeated simply because subsequent inventions improved the patented article, or because in consequence of subsequent improvements no article was in fact made in accordance with the specification," a contention which seems to traverse the second of Mr. Justice KAY's reasons enumerated above. It may be observed, however, that the Court of Appeal is satisfied with the evidence that in fact incandescent lamps were made by EDISON in accordance with the original specification—a point obviously of much importance, and one about which there has been much conflict of testimony. It has also now been admitted by the plaintiffs that the carbon of the Swan lamp was formed into its final shape before being carbonised, an admission held to be fatal to one of the points relied upon in the former action. Some subsequent disclosures led to Mr. Justice KAY's dictum, with regard to the width and vagueness of EDISON's specification, being upset on appeal, although the point is, we fancy, more one of law than of fact. If the decision of the Court below was sound at the time, it would probably not be disturbed by the fact that Mr. SWAN's lamp was not a complete success, Mr. SWAN being now in a position which can scarcely tend to induce him to set too early a date or too high a value on his own invention. Two witnesses, strange to say, Messrs. PROCTOR and HEAVISIDE, asserted that he had invented and used carbonised cotton filaments in 1879; whereas Mr. SWAN himself fixes the time in the year following. He ought to know, and of course the Court held the other witnesses mistaken.

The judgment is equally adverse on Mr. Justice KAY's third point, that, namely, in which it was objected to the specification that it did not clearly show how the invention could be carried into effect. A great deal of contradictory evidence has been submitted on this question, some authorities holding that the various filaments mentioned could be made as described, while others were equally positive that they could not. The Judges seem to have believed that the latter could have done it if they had wanted to; but it is not easy for experts to enter on an experiment of that kind with perfectly open minds, and it would perhaps be just as fair to say that the experts on the other side could not have succeeded had they not known how to do it beforehand. Here again has arisen a nice point of law bearing upon the interpretation of the Patent Act, and it is one which may be decided differently by different Judges without the least reflection on their legal knowledge or impartiality. In the present instance the three Justices of Appeal have put a liberal construction on the Act, giving the inventor the benefit of the doubt, and in the interests of inventors generally this is a course which most people will regard with approval.

The fourth objection upheld by Mr. Justice KAY related to the coating of the filament with a non-carbonisable substance; but this was not of itself a very formidable objection; and as, like the rest, it has been overruled, we need not stop to examine it further. Lord Justice LINDLEY entirely concurred with Lord Justice COTTON; but his deliverance deserves to be carefully studied by patentees because of its lucid and masterly statement of the conditions to be complied with in drawing up provisional and completed specifications. It is needless to add that in his LORDSHIP'S opinion the Edison specification came within his definition of what is absolutely required in such cases. On the question of novelty, in which the Swan lamp crops up, Lord Justice LINDLEY put the matter in a way which is worth quoting as a point of some historic interest:—"One mode of trying this question," said his lordship, "is to ask whether any one would make such a thing as Swan's lamp 'F J B 1' if he took EDISON'S specification as his guide? I am convinced he would not; he would avoid and not reproduce Swan's carbon pencil, and would adopt Edison's type of carbon in the carbon filament." On his lordship's concluding observation relating to the new departure with which he credits Mr. EDISON a greater diversity of opinion may be expected. The new departure was not the introduction of carbon filaments, but the thinning of them down. The brief remarks of Lord Justice BOWEN are noteworthy chiefly for a very decided expression of opinion that "lamps made solely on the [original Edison] patent will and do succeed." This had been stoutly contested in the present action, and as the claim is now upheld the Edison lamp may be said to be once more completely rehabilitated.

DR. ARMSTRONG ON SOME FUNDAMENTAL POINTS IN THE THEORY OF ELECTROLYSIS.

[The following remarks by Dr. Armstrong have been appended to the third report of the British Association Committee on Electrolysis, "in order to direct attention to what he considers the uncertainty in which our conceptions of the fundamental phenomena of electrolysis are still enshrouded, notwithstanding the very definite assertions of recent foreign workers."]

There can be no doubt that the work done during the past year—which in many ways has been one of remarkable activity*—has tended more and more to favour the acceptance of the dissociation theory of electrolysis, that the conviction has been strengthened that electrolysis is primarily an affair of atoms; indeed, so far has this idea gained ground, that it is even argued by Arrhenius, whose conclusions are accepted by Ostwald and others, that in dilute solutions of hydrogen chloride, for example, as much as 90 per cent. of the HCl is dissociated into its ions. Prof. J. J. Thomson, in his recent work, "Applications of Dynamics to Physics and Chemistry," has, I think, very happily criticised this conclusion in the following passage (p. 213):—

"The reasons given for this conclusion do not seem to me to be very convincing, and the experimental results on which they are based seem to admit of a very different interpretation. The supporters of this theory urge that, for the salt to produce the effect which in some cases it does, it is necessary to suppose that the molecules of the salt exert a greater pressure than they would if they occupied the same volume at the same temperature when in the gaseous condition. This reasoning is founded on the assumption that all the effects due to the dissolved salt may be completely explained merely by supposing the volume occupied by the solvent to be filled with the molecules of the salt in the gaseous condition. Now, though we may admit that the salt does produce the effects

* *Cf.* Ostwald and Van't Hoff's *Zeitschrift für Physikalische Chemie.*

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that would be produced by this hypothetical distribution of gaseous molecules, still it does not follow that these are the only effects produced by the salt. The salt may change the properties of the solvent, and the effects attributed to the dissociation of the molecules may in reality be due to this change."

Deville, who studied the behaviour of hydrogen chloride at high temperatures by means of his well-known apparatus with an internal cooled tube, observed only traces of dissociation at 1,300°, and Crafts and F. Meier could detect no appreciable dissociation in porcelain vessels at 1,500°, although in platinum at about 1,700°, according to Victor Meyer and Langer, it is to a considerable extent resolved into the component elements. That a gas of such stability should be almost entirely dissociated by mere dissolution in water is to me incredible.

Apart from actual electrolytic studies such as those of Arrhenius and Ostwald, the most important influence in forming opinion has been exercised (*a*) by Van't Hoff's masterly generalisation (*cf. Phil. Mag.*, 1888, 26, 81), to which Prof. J. J. Thomson is referring in the above-quoted passage, that the molecules of dissolved substances in dilute solutions exert the same pressure as they would if they were in the gaseous state at the same temperature and volume; and (*b*) by the introduction of Raoult's method of ascertaining molecular weights of dissolved substances by determining the extent to which they depress the freezing point of the solvent (*cf.* Chemical Society's *Transactions*, 1888, 610). While recognising the beauty of the conceptions, and while ready to admit that they may be applicable in many cases, my opinion is very much that expressed by Prof. J. J. Thomson. I agree with him that it is both possible and probable that a change in the constitution of the solvent is effected by the dissolved substance (*cf.* Chemical Society's *Transactions*, 1888, 125). The extraordinary effect on the properties of gold and copper, for example, of small amounts of certain foreign matters, so well known to electricians in the case of copper, and which has recently been brought prominently into notice in the case of gold by Prof. Roberts-Austen, may be cited in illustration of the kind of effect on the solvent which conceivably may arise.*

The arguments in favour of the dissociation theory appear, indeed, to be based on a narrow interpretation of the results; the dissolved substance alone is regarded as active, the solvent is neutral; the indubitable complexity of the phenomena of dissolution and of chemical interchange generally is entirely left out of consideration. Many chemists and physicists continue to regard values as simple constants, which there is the strongest reason to believe are composite. The law of the constancy of the so-called atomic heats of the elements is an illustration. It is well known that in the case of the majority of the elements the product of specific heat by atomic weight is approximately a constant. We are thereby enabled in many cases to determine *atomic* weights, but, be it noted, by a measurement effected with the aid of molecules, not of atoms. These molecules are undoubtedly of very varied atomic complexity, and it would seem that we are bound to assume that the nearly constant value of the so-called atomic heat is the outcome of a kind of balance—that as in raising the temperature of a solid work is done *inter-* and *intra*-molecularly, the amount of intermolecular work is greater in some cases and less in others, and the amount of intramolecular work proportionally less or greater, the amount per atom being, however, about the same in most cases. May we not interpret the simple results obtained by Raoult's method in a similar manner? Is it not probable that the effects are in reality often produced by molecular complexes of the *fundamental* molecules, the latter corresponding to the atoms to which we refer the result in discussing variation of specific heat with atomic weight? Perhaps it is only in cases in which *atomic* rearrangement has taken place that Raoult's method affords evidence of increased molecular complexity, as in the case of aldehyde and paraldehyde, for example, in such a case as that of dextrose, which, whether freshly dissolved or not, produces an effect such as is required on the assumption that its molecule has a weight corresponding to the formula $C_6H_{12}O_6$, there may be no atomic rearrangement but the mere juxtaposition of molecules involved in the formation of a "molecular" compound.

Arrhenius, Ostwald and others regard both electrical conductitvity and chemical activity as similarly conditioned by the degree of dissociation—in their opinion, very active substances, such as sulphuric acid, are to a large extent dissociated in solution; inert substances, such as acetic acid, are but to a slight extent dissociated in solution. But the adherents of this school all overlook the fact that there are two distinct theories of chemical interchange; the older theory that the interacting molecules initially combine and that the resulting complex then splits up—which may be termed the integration theory; and the more modern dissociation theory. I am led to regard the former as the more comprehensive and generally applicable, especially as comparatively so few compounds are electrolytes, and I venture to think that physicists also would incline more to my belief if they would assume a somewhat different mental attitude towards the facts, and would seek to fully unravel the entire series of changes involved in chemical interactions.

The attention of the committee has in previous years been directed to the question whether electrolytic conduction and metallic conduction are sharply separated from one another, and last year experiments by Prof. Roberts-Austen were described which appeared to show that alloys do not conduct electrolytically. Prof. J. J. Thomson deals with this question in his already-mentioned work in the following passage (p. 296):—

"There does not seem any necessity for supposing that the passage of electricity through metals and alloys is accomplished in a fundamentally different way from that through gases and electrolytes. For the chief differences between conduction through metals and through electrolytes are—(1) that in electrolytic conduction the components of the electrolyte appear at the electrodes, and we have polarisation; and (2) that the conductivities of electrolytes increase while those of metals diminish as the temperature increases.

"A little consideration will show that we could hardly expect to detect [polarisation] in the case of metals or alloys, for here instead of, as in electrolytes, the property of splitting up being confined to a few molecules sparsely scattered through a non-conducting solvent, the whole of the molecules can thus split up; thus the rate of disappearance of any abnormal condition would be almost infinitely greater than in the case of electrolytes, so that if any polarisation were produced it would probably die away before it could be detected. The only case in which we could expect to detect the appearance of the constituents of the conductor at the electrodes is that of the alloys, but even in this case Prof. Roberts-Austen was unable to detect any change in composition in the alloy round the electrodes. We must remember, however, that an alloy differs very materially from an electrolyte, because while in the latter we have a few active molecules embedded in a non-conductor, in the former it is as if the solvent as well as the salt conducted, so that the discharge is not concentrated on a few molecules of definite composition, but can travel by an almost infinite variety of paths.

"Then, again, the statements about the effect of heat on the conductivity of elements and electrolytes, though true in general, are subject to exceptions. Thus, the conductivities of selenium, phosphorus and carbon increase as the temperature increases, that of bismuth is said to increase at certain temperatures, and I have lately found that the conductivity of an amalgam containing about 30 per cent. of zinc and 70 of mercury is greater at 80 degrees than at 15 degrees. We must remember, too, that the rate of increase of conductivity with temperature for electrolytes diminishes as the concentration increases. No sharp line of demarcation can therefore be drawn between the two classes of conductors on this account.

"There does not seem any difference between metallic and electrolytic conduction which could not be attributed to the vastly greater number of molecules taking part in metallic conduction, whilst assuming that in all cases the current consists of a series of intermittent discharges caused by the rearrangement of the constituents of molecular systems."

I call attention to Prof. J. J. Thomson's remarks both on account of their suggestiveness and in order to point out that we are not in a position to make any such statement as the above regarding selenium, phosphorus and carbon. All observers hitherto have dealt with more or less *impure* substances—everyone, in fact, knows that the so-called carbon which conducts is not carbon at all in the true chemical sense. The conductivity of the substances in question may well be conditioned by the presence of the associated impurities, just as that of water appears to be, and hence their behaviour as electrolytes in respect of temperature changes; Shelford Bidwell's experiments with selenium distinctly favour this view. The differences between metals and non-metals are so great that the chemist has difficulty in resisting the conclusion that there is some very radical distinction to be drawn between metallic and non-metallic matter, although in practice it is impossible to say where metals end and non-metals begin. If it be found that the more nearly pure a non-metal is the greater is the resistance which it opposes, it will some day be possible, perhaps, to classify the elements into metals and non-metals on the basis of their electrical behaviour. In the hope of obtaining evidence on this point I have latterly been engaged in purifying selenium, with the object ultimately of determining its specific resistance; it appears highly desirable that "metalloids" such as arsenic and antimony should also be carefully examined from this point of view.

The increase in conductivity of bismuth and of Prof. J. J. Thomson's zinc amalgam at higher temperatures may well be due to a change in molecular composition, such as occurs in solid silver iodide, for example; both are cases in which the occurrence of such a change may be considered as probable. That molecular structure is an all-important element in influencing conductivity is all but established by the extraordinary diminution in conductivity effected by minute quantities of foreign elements in the case of copper, for example. In short, I am of opinion that as yet there is no experi-

* Prof. Roberts-Austen informs me that the melting point of gold is lowered to about that of zinc by $\frac{1}{10\frac{1}{2}\frac{1}{2}}$ of silicon

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mental evidence to justify any modification of the time-honoured conclusion that electrolytic and metallic conduction are essentially distinct phenomena.

Considerable discussion has taken place during previous years in the committee as to the theoretical determination of E.M.F. on the lines originally indicated by Sir Wm. Thomson from thermo-chemical data, and attention has been directed to the necessity of taking into account reversible heat effects. I may be allowed to reiterate the opinion that the evidence tending to throw doubt on Sir. Wm. Thomson's law connecting the E.M.F. of a cell with the attendant chemical changes cannot as yet be regarded as in the least degree conclusive, and I venture to offer a brief criticism on the experimental work which has been done in this direction—chiefly by F. Braun (*Wiedemann's Annalen*, 1882, 16,561; 17,593) and by Wright (*Proceedings* of the Physical Society), who have measured the E.M.F.s of a large number of different cells, and have compared the values found with those calculated from the chemical changes which they *assume* take place in them. The calculated and observed E.M.F.s were found to agree in only a limited number of cases; in a considerable number the observed E.M.F. fell more or less below that calculated; in a few it was greater; and Wright has specially instanced a number of cells in which the current flows in the opposite direction to that which was to be anticipated.

The measurement of E.M.F. was made either by means of an electrometer, or with a galvanometer *using currents of very small intensity*; and there is no reason to doubt the results. But both observers were, as I have said, content to *assume* that the chemical changes were of a particular kind, and made no attempt whatsoever to study them in detail from the chemist's point of view.

Now it has been pointed out by Laurie (*Phil. Mag.*, August, 1886) that the extraordinary results obtained by Wright with aluminium zinc cells, which give an E.M.F. opposed to that calculated from the thermal data (of no less than 1 5 volt in the case of the sulphates), are to be accounted for on the assumption that he was not dealing with aluminium at all, but with *aluminium oxide* supported on an aluminium plate. It appears to me, then, that the whole of Braun's and Wright's results are open to this criticism, as the method of measurement which they adopted is one that would permit every surface impurity, every impurity in the agents—not excluding dissolved oxygen—to exercise its proper effect. Julius Thomsen has expressly recognised this source of error, and has pointed out the absolute necessity of measuring the E.M.F. of the element in full activity if it be desired to determine the full effect produced by the chemical interchanges which are involved in its action ("Thermoch. Untersuchungen," III., p. 487). On this account his comparisons of observed and calculated E.M.F.s may well be set against those of Braun and Wright; they are as given in the following table :—

—	Chemical Energy in heat units.		Observed Relative E.M.F.
	Absolute.*	Relative.	
1 { $Zn—H_4SO_4+100H_2O$ ... / $Cu—conc.CuSO_4,Aq$ ... }	50,130	1	1
2 { $Zn-H_2SO_4Aq$ .... / $Cd-conc.CdSO_4,Aq$...... }	16,210	·32	·32
3 { $Zn—HCl,Aq$ .... / $Ag—AgCl$ .... }	54,080	1·08	1·065
4 { $Zn—H_2SO_4+100H_2O$ ... / $Carbon—HNO_3$ .... }	96,080	1·92	1·86
5 { $Zn—H_2SO_4+100H_2O$ ... / $Carbon—HNO_3+7H_2O$.. }	82,810	1·65	1·69
6 { $Zn—H_2SO_4+100H_2O$ ... / $Carbon—CrO_3+SO_3,Aq.$ }	99,790	1·99	1·85
7 { $Cu—H_2SO_4+100H_2O$ ... / $Carbon—HNO_3$ ... ... }	45,950	·92	·88
7b { $Cu—H_2SO_4+100H_2O$ ... / $Carbon—HNO_3+7H_2O$.. }	32,680	·65	·73
8 { $Fe—FeCl_2,Aq$ .... / $Carbon—Fe_2Cl_6Aq$ ...... }	44,410	·89	·90

* To reduce heat units per dyad-gramme-molecule direct to volts use the divisor 46,000. The column headed "Relative" in the table would then run, 1·1, ·35, 1·18, 2·03, 1·80, 2·16, 1·00, ·71, ·97.

When it is borne in mind that in the case of nitric acid the products of change gradually accumulate and produce an effect, the agreement between theory and practice is remarkable.

Braun argues that "chemical energy" is of the form of heat energy, and that in its *conversion* into electrical energy in the cell there must therefore necessarily be some loss—some degradation; he terms that fraction of the total energy which takes the form of current the *electromotive efficiency* (Helmholtz's "Freie Energie"), and seeks to connect this with the dissociation temperature of the compounds formed at the electrodes. But if, to use Faraday's words, "the forces termed chemical affinity and electricity are one and the same," there is, I imagine, no *à priori* objection to be urged against Sir Wm. Thomson's law.

Braun has based a determination of the "electromotive efficiency" of a number of chemical changes on the assumption that the E.M.F. developed, for example, between silver, silver bromide, bromine and platinum, is to be regarded as developed simply in the formation from silver and bromine of silver bromide. The value found was 84, that deduced from the heat of formation is 91, so the electromotive efficiency is $\frac{84}{91} = \cdot 93$. The experiments were made in a very careful manner, and exceptional precautions were taken in purifying and drying the materials, the bromine used being purified by Staas's method. But the fact that the current *was* produced between silver, bromide and platinum, and between silver coated with silver bromide, bromine and platinum is, to my mind, sufficient to throw doubt on the results. It is impossible to prepare *pure* bromine, and it is a fair assumption to make that, if the materials had been pure, no current would have been observed. The determination of the E.M.F. is therefore of uncertain value: the number deduced cannot have been the outcome simply of the formation of silver bromide, as secondary change must have taken place to some extent.

I therefore venture to think that, up to the present, no experimental disproof of Sir Wm. Thomson's generalisation has been given; on the other hand, the fluctuations in E M.F. which accompany slight changes in composition—such as have been so clearly brought out by Lord Rayleigh's investigation of the Clark cell and by Wright's and Fleming's investigations of the Daniel cell—and also the influence which every change in the conditions exercises on the course of chemical change, would appear to favour the assumption that the electromotive efficiency of chemical change does not differ from the theoretical to the extraordinary extent that Braun suggests.

Before the temperature of dissociation can be taken into account as suggested by Willard Gibbs, we require to know to what extent this depends on the nature of the surface in contact with the dissociating substance.

It is also desirable that a clearer statement of the nature of the reversible heat effects should be given. I can picture to myself that on passing a current across a metallic junction the molecules became somewhat deflected from their original positions, or rotated, and that heat is developed on their subsequent return towards the normal position; but if this be the nature of the Peltier effect, and the converse action occur when thermo-electric currents are developed, it does not appear probable that the reversible heat effects at metal-liquid and liquid-liquid junctions would be of the magnitude to account for the extraordinary differences said to obtain in many cases between observed and calculated E.M.F.

LEGAL INTELLIGENCE.

Edison and Swan Electric Light Company v. Holland and Others.

Judgment was delivered in the Court of Appeal on Monday, February 18, in the case of the Edison and Swan Electric Light Company *v.* Holland and others (the Anglo-American Brush Electric Light Company, Limited, third parties), the judges being Lord Justice Cotton, Lord Justice Lindley, and Lord Justice Bowen.

Sir Richard Webster, Q.C., M.P. (Attorney-General), Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Bremner appeared for the appellants; and Sir Horace Davey, Q.C., M.P., Mr. Finlay, Q.C., and Mr. J. C. Graham for the respondents.

LORD JUSTICE COTTON said: This is an action brought against the defendants in respect of two patents, both of which were contested. The plaintiffs have sought to claim infringements of those patents. One of them was a patent granted to Cheesbrough. In respect to that Mr. Justice Kay decided in favour of the plaintiffs, and granted an injunction and consequential relief. As regards the other patent, which was one obtained by Edison, and dated the 10th November, 1879, he decided against the plaintiffs, and hence the appeal to us.

Now this patent has been before this Court before, and I had the advantage, or disadvantage, of being one of the members of the Court on the previous occasion. Then there was a difference of opinion between myself and the other Lords Justices as to the true construction of the specification, but I consider myself bound by the decision of the Court on that point, and in my opinion, except on questions of facts, which, of course, must be decided on the evidence in this action, the Court ought to consider itself bound by the previous judgment, which was in favour of the patent now vested in the plaintiffs—Edison's patent. In the previous case the Court held that there was no anticipation of the invention claimed by Edison, that it was a good subject matter for a patent, being for combination, many parts of which were not new, but which were rendered useful by a carbon bridge or burner, described as a filament, which the majority of the Court held not to be confined to the particular things described as filaments in the specification, but I think held that it must be substantially the same as regards these characteristics as the particular filaments described in the specification. The Court then decided that the utility of the invention was established. Here there was a great effort made to contest the utility of the invention. This was based principally on the contention that no successful incandescent lamps were made in accordance

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with the specification of the 10th November, 1879, and without further improvements. The invention for the improvement of carbon filaments followed quickly on the patent of November, 1879, which greatly assisted in the manufacture and the utility of the burner of the incandescent lamp of November, 1879. That in my opinion was a useful combination; and a patent is not to be defeated simply because subsequent inventions improved the patented article, or because in consequence of such subsequent improvement no article was in fact made in strict accordance with the specification. But, in my opinion, it was established on the evidence that in fact incandescent lamps were made by Edison in accordance with the specification of November 10th, 1879, and were sent by him to Dr. Hopkinson, and publicly run by him in March, 1880. I do not see any facts now brought before us that ought to have induced the Court to depart, or to justify the Court in departing, from the previous decision of the Court on the question of the invention being useful, and being a good subject matter for a patent.

We then come to the objection of want of novelty, which is a question of fact. The only alleged anticipation which I need consider is that of Swan's lamp F J B 1, exhibited in December, 1878, and February and March, 1879, by Mr. Swan. In the previous case, on the evidence then before us, I thought this lamp was, on the construction put by the majority of the Court on the specification, an anticipation, but how does the evidence now stand? It is now admitted that the carbon burner of Swan's lamp was formed into its shape before it was carbonised, and this removes one of the points much relied upon by the plaintiffs in the former action. But we have now evidence, which was not before the Court in the former action, of what was being done by Mr. Swan and Mr. Stearn, after the experimental trial of this lamp. We have the evidence of Mr. Swan and Mr. Stearn. We have had before us the lamp F J B 1, and we have the letters written by Stearn to Swan in 1879 and in 1880, which were apparently read by counsel to show what was being done by Stearn and Swan. We see that that lamp was treated by them as a failure, and that their attempt to correct its defects led to lamps which differed more widely from F J B 1 than that lamp described in Edison's patent. This evidence assists the conclusion at which the Court arrived in the former action, that Swan's lamp in 1879 was not a success, and I think enabled me to come to the conclusion that this lamp was an experimental lamp which failed, and which was abandoned, and that the difference introduced by Edison was one which changed failure into success.

But it was contended by the respondents that, in fact, Swan had used for electric lighting incandescent lamps with carbonised thread burners before the 10th November, 1879. Two witnesses, Proctor and Heaviside, stated that carbonised thread lamps were in 1879 used by Swan. There is no ground for imputing dishonesty to these witnesses, but there was the direct evidence of Swan that he did not make any thread carbon lamp before 1880 or before the trial, the date of which is fixed at January, 1880; and I am satisfied that the witnesses were mistaken in fixing the date at 1879. Reliance was placed by the respondents on a lamp made by Bernstein, not an anticipation of Edison's patent, for it was not made until after 1879, but as showing that Swan's lamp was a practically useful one; but though Bernstein's lamp has a bridge or conductor or pencil of carbon like F J B 1, it has a different connection with the leading wire, which probably obviates some of the difficulties which prevented Swan's lamp from becoming a success.

Then I come to an objection which was much relied upon by the defendants, which was not raised in the former action, and which is now supported by a good deal of evidence. The objection, taken as a whole, was that the specification did not sufficiently show how the invention is to be carried into effect. It is necessary that this should be done so as to be sufficiently intelligible, and to enable the thing to be made without further invention, as was pressed upon us, not by an ordinary workman, but by a person described by Lord Ellenborough in Haddart *v.* Grimshaw as "a person skilled in the particular kind of work," or as described by another learned judge as "a person conversant in the subject." In my opinion it is not necessary that such a person should be able to do the work without any trial or experiment, which when it is new or specially difficult may frequently be necessary, however clear the description may be. One of the principal subjects of the attack was that part of the specification which gave directions for the making of a combination of lampblack and tar to form a material for the filament to be carbonised. Before the experiments, which by the direction of Mr. Justice Kay were made under the supervision of Prof. Stokes, the defendants' witnesses said that useful filaments could not be made out of this material, and Prof. Crookes was particularly strong in his ridicule of the idea that tar putty could be practically useful. Gimingham, a young man in the employ of the plaintiffs, produced and proved lamps with burners made of tar putty filaments, and after the experiments made before Prof. Stokes the defendants contended before us, without any support from the evidence, that the material could not be effectually prepared without a trade secret, which they said had only recently (that is, during the trial of the action) come to the knowledge of the plaintiffs, and probably had been communicated from America. It was said that this secret was the necessity of kneading the material for a length of time, and with the exercise of great pressure. In fact, Gimingham had for the trial of the previous action made lamps with tar putty filaments which were made exhibits in this action, and although there are no express directions in the specification how the tar putty is to be prepared, it is stated that the tar putty can be rolled into a thread as small as seven-thousandths of an inch, and I think it would be obvious to any intelligent workman who wished to prepare the material that it must be kneaded so as to make it perfectly homogenous and to prevent any breaking of the thread in consequence of any particle of lampblack not being perfectly amalgamated with the tar. I think that this objection fails.

But it was contended that lamps with tar putty filaments had not sufficient endurance to make them practically useful. No point was made of this before Prof. Stokes, so that no experiments were made to test this question. In fact, in the evidence before us many of these lamps are shown to have been run a sufficient time to prove that they could not be considered failures in this respect.

Another objection taken to the specification was that no sufficient directions were given as to the carbonisation of the filaments. The specification on page 3 says, "a cotton thread properly carbonised," and speaking of the thread of tar putty "this" (the tar) "may be carbonised in a closed chamber by subjecting it to a high heat," but no directions are given as to how this is to be done. Before the experiments made under the supervision of Prof. Stokes it was said that carbonising the filaments in a closed chamber without any packing, or with a packing of sand, which was suggested by Sir Frederick Bramwell, was impossible, as the filament would be reduced to ash. But this was proved to be unfounded, and before us it was still contended that no sufficient directions as to the mode of carbonisation were given. Carbonisation is a well known term, the ordinary process having been described as roasting without the presence of oxygen. This was well known and practised before the date of the patent, and Sir Frederick Bramwell in his evidence said that any person who knew the ordinary process of carbonisation would succeed in carbonising the filament. But it was strongly contended by the defendants and by some of their witnesses that such tender things as filaments could not be carbonised in closed chambers without being protected by packing, which the specification did not direct to be adopted. In fact, filaments were, as sworn by the witnesses of the plaintiffs, and demonstrated by the experiments made before Prof. Stokes, successfully carbonised in closed chambers or boxes without packing. Moreover, although the specification says nothing about packing, any skilled workman conversant with carbonisation would take the ordinary process of packing to exclude oxygen, and would, I think, know that when so delicate an article as a filament is to be carbonised the greatest care would be necessary to prevent any possible access of oxygen. It is true that there was no trade in carbonising anything so delicate as these filaments, but great care only in exercising a known process and applying it to an unusually delicate article was wanted, and no inventions would be necessary. When the defendants' witnesses failed in carbonising the filament, I think they did not use a reasonable care to exclude oxygen, as shown in their using porous crucibles. I am of opinion that this objection also fails.

Another point urged by the defendants was that the coating with a non-carbonisable substance described in the patent was injurious. The result of the evidence is that when the coating is a thin one the process can be and is done without any injurious result. But then it is objected that the specification did not direct a thin coating, and it was objected, and so held by Mr. Justice Kay, that this thin coating was a mere pretence of coating and dusting only. But it appears in the evidence of Mr. Crookes that he had himself adopted the same method of dusting as was adopted on behalf of the plaintiffs by this process. The process was I think in the specification proposed as preventing the filaments of the putty from sticking together during the process of carbonisation; and what I have said about Mr. Crookes I think shows that the process which produces the so-called "dusting" must be considered that which would naturally be adopted. I think that this objection also fails.

I have dealt with the principal points urged by the defendants, though shortly, in order to avoid the extreme length which would be necessary if I were to deal minutely with the various points. In my opinion the plaintiffs are entitled to judgment, and the appeal must be allowed.

LORD JUSTICE LINDLEY: The validity of the patent in question in this appeal is disputed on two broad grounds, namely: first, because the patentee has not particularly described and ascertained the nature of his invention; secondly, because he has not particularly described and ascertained in what manner the same is to be performed. The 9th Section of the Patent Act of 1852, under which the plaintiffs' patent was granted, imposes upon the patentee the necessity of complying with both of these conditions in order to sustain his patent, and the patent is bad if he fails to perform either of them. The two conditions, although often confused and overlapping, are really distinct, and it is always necessary to keep each clearly before one's mind, and not to commit the mistake of supposing that compliance with one is necessarily compliance with the other.

The first condition imposes upon the patentee the necessity of stating in clear and intelligible language what his invention really is, so that they may know, and that others may know, what addition the patentee says he has made to what was known before, so that they may know what they are not at liberty to do without his consent during the existence of the patent—in other words, so that they may know what the monopoly is that is granted to the patentee. The nature of the invention must be stated both in the provisional and in the complete specification; but whilst it is sufficient in the provisional specification to state the nature of the invention in general terms, it is necessary in the complete specification "to particularly describe and ascertain it."

The second condition imposes upon the patentee the necessity of stating in clear and intelligible language in what manner the patented invention is to be performed, so that others may learn from the specification how practically to avail themselves of the patented invention when the patent has expired—how they are to do what is necessary to carry out the new invention, the nature of which has been previously described. This condition applies to the complete specification only. There is no necessity for stating in the provisional specification how the invention is to be performed.

With reference to the degree of clearness and distinctness of the language necessary to be used in order to comply with these conditions, it is obvious that no hard and fast rule can be laid down. The degree of clearness could only be stated in language which itself admits of considerable latitude of interpretation. On the one hand, the patentee must make the nature of his invention and how to perform it clear and intelligible; on the other hand, it is not necessary for him to instruct persons wholly ignorant of the subject matter to which his

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invention relates in all that they must know before they can understand what he is talking about. The patentee is adding something to what is known before, and he does all that is necessary as regards the language he uses if he makes the nature of his invention and how to perform it clearly intelligible to persons having a reasonably competent knowledge of what was known before on the subject to which his patent relates, and having reasonably competent skill in the practical mode of doing what was then known. In complying with the first condition—that is, in describing the nature of his invention—the patentee does all that is necessary if he makes the nature of his invention plain to persons having a reasonably competent knowledge of the subject, although from want of skill they could not themselves practically carry out the invention. In complying with the second condition—that is, in describing in what manner the invention should be performed—the patentee does all that is necessary if he makes it plain to persons having reasonable skill in doing such things as have to be done in order to work the patent what they are to do in order to perform his invention. If, as may happen, they are to do something the like of which has never been done before, he must tell them how to do it if a reasonably competent workman could not himself see how to do it on the reading of the specification, or on having it read over to him. The principle to be applied to the language used to comply with the two conditions is the same for both, and while one class of persons may understand only one part of the specification, and another class only the other, yet the patent may be valid. In a well-drawn specification the two conditions that have to be complied with are kept distinct, but in many specifications this course is not pursued. The nature of the invention and the manner of performing it are often described together. It may be that one set of words sufficiently discloses both the nature of the invention and the mode of performing it, but it may be, and sometimes is, very difficult to secure the two and say that both are sufficiently described. Still, if they are, in fact, sufficiently described, the conditions must be held to be complied with, however difficult and troublesome it may be to arrive at a conclusion.

I have been induced to deal at some length with the above matters because of their importance in the present case, and of the danger of losing sight of the principles by which the Court ought to be guided in deciding it.

I proceed now to inquire whether these two conditions have been performed, and I will take them in the order in which they logically present themselves. First, as to the nature of the invention. This Court has had to consider this matter before, and although there was a difference of opinion amongst the members of the Court, the decision of the Court was, as I understand it, first, that the expression "carbon filament," on which so much turns, was sufficiently clear and definite; second, that the nature of the invention was sufficiently described and ascertained, and was summed up in the second claim; third, that the second claim was in substance a claim to make a combination of a carbon filament with any receiver made entirely of glass, through which any leading wires pass, and from which air is exhausted; fourth, that the plaintiffs' carbon filament was essentially different from the carbon pencil used by Swan in his lamp F J B I, and that Swan had not by that lamp anticipated the plaintiffs' patent. The patent was upheld, notwithstanding the very large dimension of the second claim as construed. That decision is in my opinion binding upon us so far as the construction of the specification is concerned, but no further. I do not regard the decision as binding upon us upon the question whether the relative conditions to which I have alluded have been performed or not, for those questions depend not only on the construction of the specification but on the evidence as to the previous state of knowledge and as to whether a person of reasonable skill could at the date of the patent carry out the invention without further instruction than the specification gives him. I have, therefore, whilst taking the construction of the specification as settled, considered myself at liberty to exercise my own judgment on the effect of the evidence in this litigation. The construction of the specification which I consider binding involves three points, namely, first, that the specification is not too vague and unintelligible to be construed by the Court; secondly, that what is meant by a carbon filament is reasonably plain in the specification itself; and, thirdly, that the second claim, as construed by the Court, is not so wide as to invalidate the patent. The meaning of the expression "carbon filament" appears to me to be the crucial point for determination when we are dealing with the question whether the nature of the invention has been sufficiently described. This point, moreover, is in my judgment by far the most difficult in the whole case. Everything, I think, turns upon it. I consider it settled. I was no party to the decision, and the case will probably be appealed; but I think it desirable to state that, after much consideration and doubt, I have come to the conclusion that what is meant by the expression "carbon filament" can be gathered from the instances given in the specification, and that what is meant is any thread which can be made to bend in the required form, and can be carbonised when so bent. The thread, as shown by the examples, may be a fibre or a group of twisted fibres, or, as is to be got from the carbon of lampblack, it may be an artificial substance pressed or rolled into a thread or wire-like form. The evidence shows that as a fact the expression "carbon filament" was new as applied to electric lighting. Its meaning, or, in other words, the sense in which it is used by the patentee, must therefore be gathered from the specification. The sense in which the patentee has used the expression "carbon filament" can, in my opinion, be gathered from the typical examples given in the specification, and referred to in the judgement of Lord Justice Fry in the former case. The size of the filament is not stated, but it is quite clear from the objects to be attained that it must be long and thin, and nothing more definite is necessary to be stated. Having arrived at this conclusion, it follows that, in my opinion, the patentee has sufficiently described and ascertained the nature of the invention.

The next thing is to consider whether he has sufficiently described in what manner the same is to be performed. This is a pure question of fact and is in no way touched by the previous decision of this Court. Mr. Justice Kay has, however, found this against the patentee. Having carefully attended to the evidence and his judgment, I have come to the conclusion that I am unable to agree with him, and I cannot but doubt whether he would have arrived at the same conclusion if he had had the advantage, which we had, of hearing the Attorney-General's reply to the defendants. The defendants, in the first place, endeavoured to make out that carbon filaments could not be made as described by the patentee. The evidence on this point was so conflicting that Mr. Justice Kay called in an expert, Prof. Stokes, to assist him. This gentleman's report is absolutely conclusive in favour of the patentee upon the question whether carbon filaments can or cannot be made as described. On this point the defendants contend that no competent workmen could have made carbon filaments according to the specification without further instructions than are there given. If it be meant that few competent workmen could make them without some practice, I think the contention is well founded. But this is not sufficient to invalidate the patent. If a person is told to carbonise a thread, and for want of thought or practice he takes a porous crucible for the purpose, and does not protect his thread and fails, when, if he had packed his crucible, or had taken a non-porous crucible, he would have succeeded, his failure to carbonise can hardly be said to be the fault of his instructor, if a little thought and consideration would have shown him that a packed crucible or a non-porous crucible was the right one to employ. The fact that a workman might use a wrong tool when he has the right one, which a little thought would lead him to see ought to be used, does not warrant him to say that the specification is bad if it does not tell him which tool to use.

Again, with respect to the tar putty, the object to be attained is plain. The putty must be kneaded, so that it may be rolled out thin, without mark or flaw. Practice alone can teach any man how long and how hard he may knead; if he stops too soon and fails, is it the fault of the patentee? I should say certainly not. A similar observation applies to coating with a non-conducting, non-carbonisable substance. If the coating is made lightly by dusting all goes well, if too much is put on failure is the result. A little practice is all that is required. I feel the great difficulty of describing in words the distinction between an amount of practice without which failure is probable, but the necessity for which does not destroy a patent, and an amount of experiment and practice without which failure is certain, and the necessity for which destroys a patent. The test, however, by which to decide such a question is, I think, to be found by asking whether anything new has to be found out by a person of reasonably competent skill in order to succeed if he follows the direction of the patentee in his patent. If "yes" the patent is bad; if "no," good. So far as this point is concerned practice is one thing and experiment and trial are something different. Upon this point I have derived considerable assistance from former judgments of the late Master of the Rolls and other learned judges. It is settled that the patentee who does not disclose the best method known to him of carrying out his invention does not comply with the second of the conditions to which I have before referred; but if a patentee says that something must be done which a reasonably competent man would know how to do, the patentee need not tell how to do it nor warn him to be careful, and to exercise such forethought and attention as the delicacy of the process to be used or the material to be employed plainly demand. The evidence upon the question as to whether at the date of the patent a reasonably competent man could make carbon filaments without further instruction than is given in the specification or without further experiments was undoubtedly conflicting, and Mr. Justice Kay who saw the witnesses came to the conclusion that further instruction was necessary. The Attorney-General, however, convinced me that on that point Mr. Justice Kay was mistaken. I cannot myself come to the conclusion that the patentee has kept back any secret that he possessed by virtue of which he could in 1879 make carbon filaments better than any other persons could have done who followed the directions contained in his patent, and I think therefore that he is entitled to succeed. To ensure success, all that is necessary is carefully to follow the instructions there given, bearing in mind the objects to be attained and that the filaments are extremely delicate and can easily be destroyed. That is, in my opinion, a fair result of the evidence, and the fact that Edison in later years gave particular instructions as to the mode of carbonising, &c., only shows that he had then ascertained that those instructions were necessary to enable a competent man to obtain the desired results. It cannot, I think, be inferred that in 1879 special instructions were necessary to enable a reasonably skilful man to ascertain what the specification had failed to state must be done. The evidence on this matter is no doubt conflicting, but I cannot agree in thinking that the manner in which the invention is described is not stated sufficiently accurately for the purposes of the patent. If this were really true, it would have been found out long ago—at least, so far as carbonising is concerned.

There remain, further, two other matters for consideration, namely, novelty and utility. The novelty depends on whether Swan's lamp F J B 1 was an anticipation, but I am convinced that Proctor and Heaviside were wrong as to the date of the lamps made by Swan. The correspondence referred to by the Attorney-General is conclusive as to this matter. The lamp F J B 1 was held by this Court in the action against Woodhouse and Rawson not to be an anticipation of Edison's patent, but it was then supposed that the carbon pencil used in it was carbonised after and not before it had assumed its final shape. This was a mistake, and was admitted to be so in this action. The question of anticipation must be considered anew from the evidence before us. If Swan's lamp F J B 1 had been a success instead of a failure, it would, in my opinion, have been an anticipation of Edison's patent. The evidence, however, shows that it was a failure, and that Swan had not got the key to success. His own efforts to improve this lamp show that he was not thinking of filamentous incandescent carbons, but of other matters. Still his lamp did

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emit light for a time, and was very near, although in my opinion not quite, an anticipation. It was in truth an unsuccessful experiment. I agree with Lord Justice Fry in thinking that "the point at which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention and produced a new result." Regarding the lamp F J B 1 as an unsuccessful experiment, this part of the case is governed by the principle laid down in a case reported in "7 Chancery Appeals." The question of novelty, which I am now considering, is closely connected with, although really different from, the question of whether the specification is sufficiently descriptive of the nature of the patented invention. Given the Swan lamp F J B 1, can it be said that the specification is descriptive of what is known at the date of this patent. Did he sufficiently describe the nature of what he added? In my opinion he did not in words distinguish his lamp from Swan's, but gave a description of a new type of body to be rendered incandescent, or, if I may use such an expression, a new type of wick. One mode of treating this question is to ask whether anyone would make such a wick as Swan's lamp F J B 1 if he took Edison's specification. I am convinced he would not. I believe he would not reproduce the Swan carbon pencil, but would try to get an incandescent light with carbon—that is, the carbon filament. The two may be made to shade off into each other until it becomes impossible to draw the line sharply between them. But this does not prevent a man from perceiving the difference between the two types, and from adopting the one which succeeds in preference to the one which fails.

There remains the question of utility. Edison's patent is said to be of no use, and the proof of this statement is said to be furnished by the fact that lamps are not made according to the patent by the patentee himself. The utility of the patent must be judged by reference to the state of things which then obtained. If the invention was then useful, the fact that subsequent improvements have been made, and rendered it obsolete and commercially bad, does not invalidate the patent. Such has been the fate of lamps made in the way described in Edison's specification. Such lamps appear to have been made and sent to him, but they were so soon improved that they at once ceased to be used in their original form. But lamps having carbon filaments in combination with the other essentials mentioned in the second claim are in constant use, and their utility is proved by the fact that this particular combination is used by the defendants, and by everyone, in fact, who makes incandescent electric lamps. The utility of the patented invention being established, the above combination is incontestible, and Mr. Justice Kay's opinion to the contrary is, I think, to be attributed to the view he took of the construction of the patent, a matter which, as I said before, I consider settled by the previous decision of this Court.

Before concluding I ought to notice the very formidable objection taken by Mr. Justice Kay to the validity of the patent, on the ground that the second claim is for a monopoly of incandescent lamps containing a filament of carbon for a burner, and that such a claim is far too wide considering how much Edison had invented. Whether the view here taken of the patent is correct or not turns, in my opinion, upon what Edison did when he introduced the carbon filaments. That was, I take it, a new departure of the highest importance in electric lighting, and if this be so the claim is not too wide.

For the reasons above stated I am of opinion that this patent, construed as it has been by this Court, is valid, and that the appeal ought to be allowed.

LORD JUSTICE BOWEN: In order not to add more than is necessary to the voluminous literature on the subject of this patent I will express my views as briefly as possible.

As regards the construction of the second claim, I think that we ought to follow the principle of what has been already decided by the majority of the Court in the case of the former action, but as I retain the same opinion as I then formed, the point becomes less material. The patent appears to me to claim in distinct and unmistakable language every combination of any carbonised filament with any receiver of glass through which leading wires pass, and from which the air is exhausted. Whether a claim so framed is too vague or too wide to be the subject of an independent patent, or whether it is wanting in novelty or utility, constitute an inquiry which, in my opinion, in part at all events, may be said to be bound up with questions of fact, and as far as all such points are concerned I think it desirable to judge this appeal *de novo* upon its independent merits. Construing claim 2 as embracing all combinations such as I have mentioned, is it too vague? I see no reason to doubt that in the year 1879 the term "filament," though new at that date as regards electric lighting, would nevertheless convey to the minds of ordinary persons of the class to whom this specification was addressed the idea of a slender thread, or thread-like substance, and it seems to me that the specification indicates that the thread or filament was first to be formed, and then to be subsequently carbonised. On page 2 of the patent the thread is distinguished from a rod. "Heretofore," says Mr. Edison, "light by incandescence has been obtained from rods of carbon. I have discovered that even a cotton thread properly carbonised will produce the requisite effect." The instances given in the specification which are enumerated in the judgment of Lord Justice Fry and myself in the previous appeal, and in the judgment of Mr. Justice Kay, are illustrations of the sense in which the term, which appears to me to be in itself intelligible, is used. The term "filament" is nowhere defined. It is a descriptive term, not a definition. But it appears to me to indicate the nature of the particular factor in the combination in a way that describes and ascertains the nature of the invention, so as to render it plainly intelligible to a skilled person of the class to whom the specification is addressed—language which embodies the old law, but which is tersely expressed in Lord Herschell's judgment in the case of Badische Anilin Fabric *v.* Leverstein, reported in 12 "Appeal Cases." The merits of a filament, as distinguished from a rod, are manifest. The filament, or thread, has an extremely small sectional area; it is flexible before carbonisation, and resilient afterwards. It is true that its merits are not explained, but I know of no law which renders it incumbent on the patentee in such a case to explain them. It appears to me, moreover, to be proved not only that every successful lamp since 1879 which is of avail for multiple arc lighting has employed a filament, but also that there is no proof that any filament cannot be adapted to the patented combination. If this is so, why is the claim too wide? That is not the fault but the virtue of the invention that it covers so large a field. We have been pressed with the argument that the Edison patent is useless, and that no lamp in the market has been made exclusively on the patent of 1879 without the aid of subsequent improvements. Improvements of real value followed with great rapidity on the patent which were actually utilised. Their rapid succession does not destroy the legal validity as regards the usefulness of the original combination to which such improvements were felicitously applied. The utility of this invention which was admitted in the Woodhouse case has been challenged in the present action, but I think unsuccessfully, and the evidence shows that lamps made solely on the patent will and do succeed, although subsequent improvements have been generally engrafted on the original design. Was F J B 1 an anticipation? We know now, what the Court did not know in the last action, that the carbon conductor of F J B 1 was formed before it was carbonised. Was it a filament? The question is one of degree. I doubt whether it is a filament, and I still more doubt whether any one who saw it would understand it to be such; but in any case I think F J B 1 was never more than an experiment, which was unintelligible, on account of its failure and barrenness of all fruit, and that it was regarded even by its inventor as practically valueless in the race. The correspondence between Messrs. Swan and Stearn shows, I think, to demonstration that till the middle of the year 1880 Mr. Swan did not consider himself to be upon the right track. The dates put forward by the witnesses Proctor and Heaviside seem to me to be unreliable and inaccurate, but I think there is reason for believing that it was Mr. Edison's patent which led back the world of electricians to the true path. Certainly, from the date of its exhibition that lamp F J B 1 disappeared from history until it was exhumed for the purposes of the trial in the Woodhouse case.

With respect to the remaining points used in the arguments before us I have nothing to add to what has been said by my brothers. I think this patent constituted a new departure in electricity, that the specification sufficiently describes and ascertains the nature of the invention, and that no reasonably competent operator alive to the delicacy and care obviously requisite in forming and carbonising so slight a thing as a filament ought, without any exercise of invention, but with reasonable watchfulness and only fair good will, to have been embarrassed in making and carbonising Mr. Edison's filaments. The appeal, in my judgment, should be allowed, with the usual results as to the costs; and I think I ought in conclusion to express my own obligation for the conspicuous clearness and ability with which this case has been placed before us at the bar.

On the application of the ATTORNEY-GENERAL the usual certificates as to the validity of the patent, costs, delivery over of the stock of infringing lamps on affidavit, and inquiry as to damages, were granted as against the defendants.

The ATTORNEY-GENERAL then referred to the position of the Anglo-American Brush Company, who had intervened as third parties, and had said they were the makers of the lamps, and would indemnify the defendants. Sir Horace Davey, in the Court below, had suggested that it would be more convenient that the Anglo-American Brush Company should be put in direct relation to the plaintiffs. He now desired to argue on the part of the plaintiffs before their lordships or some other Court, whether they were not entitled to have an injunction in this action as against the third parties. This was a case in which third parties would clearly be held to be estopped; and he was not sure whether the plaintiffs were not entitled to further relief. In the Court below the Brush Company had appeared, and throughout conducted the matter; they became parties to the action, and the issue was tried directly between them and the plaintiffs; in fact, the whole question of the validity and of the infringement was fought between the plaintiffs and them, and not between the plaintiffs and Jablochkoff and Holland.

LORD JUSTICE COTTON: I am afraid you are introducing a new practice not justified by the orders or the Act of Parliament. You cannot get an injunction except as against the defendants, their servants, and agents.

The ATTORNEY-GENERAL said he was not quite clear as to what really they were entitled to against these third parties on this point; but he contended that he was entitled, as of simple right, to an order for costs in the action, and the appeal as against them, they having appeared as the real defendants, and conducted the whole matter on an indemnity. He should have been glad to have had time to consider more thoroughly the question of the injunction. Having cited various authorities in support of his contention the Attorney-General, after further argument between the Judges, himself, and Mr. Aston (who followed on the same side), asked leave, if necessary, to amend the statement of claim, so as to put the Brush Company in the position of defendants.

Sir HORACE DAVEY, for the respondents, argued that if the plaintiffs deliberately chose to sue Holland, who used the lamps, instead of suing the persons who, it was alleged, made and furnished the lamps, it would be contrary to all precedent to allow the plaintiffs, after having got judgment, to amend by making the Brush Company defendants for the purpose of obtaining relief against them.

LORD JUSTICE COTTON: I do not think we need hear you further on the question of amendment; but do you object to an order being made for costs against you?

Sir HORACE DAVEY: As a matter of fact my clients do not care, but if your lordship asks me whether, as a matter of form, it would be right, in my submission it would not. I do not, however, think the question of costs worth discussing, because we intend to pay the costs.

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The ATTORNEY-GENERAL having replied,

LORD JUSTICE COTTON said the point raised was a curious one, but it arose simply after judgment. The plaintiffs now claimed to treat the third parties as if they were defendants, not only in the way of making them pay the costs, but also in the way of granting relief against them by granting an injunction and consequential relief. As regarded that he thought that the plaintiffs were wrong. Third parties were not defendants. If a plaintiff had a direct claim against a third party, as soon as that was known the proper course was to amend the statement of claim and make him a defendant, and then the Court had all that jurisdiction as against the defendant which was obtained by serving that party with a writ and bringing him in as one of the parties to the action. Why that was not done in this case he could not understand, except that possibly the plaintiffs did not like to bring in another person against whom they would be liable for costs if they failed, as they did before Mr. Justice Kay, as regards the violation of the Edison patent. One did not wish that there should be unnecessary litigation, but he did not see that, for the best reasons, they could assume a power which, in his opinion, they had not got. It would have been very easy when the third party came in and desired to defend the action to obtain directions that he might have that liberty given on his undertaking to submit to whatever judgment the Court might think fit to give against him as being really the person who ought to have been made the defendant; but that was not done. The order which was made was simply in these terms—that he should be at liberty to appear at the trial of the action and take such part therein as the judge should direct, "and the said Anglo-American Brush Electric Light Company shall be bound by the decision of the Court in this action in any question as to the above indemnity which may arise between that company and the defendant." The plaintiff was satisfied with that. He ought to have said "No, that will not do for me; other terms ought to be imposed upon the third party." The proper course for the plaintiff to have brought the third parties within the region of the jurisdiction of the Court would have been to have amended his statement of claim, and to say that the third parties were the real persons who were disputing their rights in the patent, and who were making those things which the plaintiff alleged were an infringement of the patent. That course, for some reason which he did not know, had not been taken. In his opinion the Court had no jurisdiction to make a decree against this third party, as if he was a defendant, or to grant an injunction against him, and to grant damages against him in this action. It was a new departure. Whether the Anglo-American Brush Company would be unwise enough to dispute the plaintiffs' right as regarded this patent when another action was brought against them he could not suppose. Then the Attorney-General asked leave to amend, and Mr. Aston said, that he (the learned judge) had frequently expressed the view that they ought to make such order as the Court ought to have made below, and to make such amendment as might be necessary. What was the course taken by the plaintiffs on the trial before the Court below? In the Court below they never asked for this relief as against the third party. It was very true there was an expression by Sir Horace Davey which was relied upon that the third party ought to be put in "direct relation" to the plaintiffs. He did not quite understand what that meant; it was not as clear as Sir Horace Davey's expressions usually were, but the parties did not act upon that. It might have been material then, because all the costs that were given were the costs of the defendands as regarded that part of the action in which the plaintiff failed. The costs were given against the defendants as regarded that part of the action in which the plaintiffs' succeeded. In his opinion it would be wrong under those circumstances, and having regard to the course which was adopted by the plaintiffs, now to grant liberty to amend to enable the Court to grant different relief against the third party other than that which was asked for at the trial of the action. As to the question of costs, the third parties having appeared upon the appeal, and having been served with notice of appeal, there would be no difficulty about making an order against them for the payment of the costs of the appeal, and in his opinion the Court had jurisdiction under Rule 54 to make them pay the costs. Therefore, as regarded this part of the action, he thought it would be wrong to alter the judgment, but as regarded the other part of the action they might, when they altered the judgment of Mr. Justice Kay, make an order against the third party, as well as against the defendants for the payment of the costs of the appeal.

LORD JUSTICE LINDLEY said that in substance the third parties were the people who fought the plaintiffs, and if he had tried the case, and come to the same conclusion as he had done upon the merits, and had been asked to make the third parties defendants, he should have done it without the slightest hesitation, and he was not at all sure if he had been sitting alone upon appeal that he would not have done it now. He thought there was a power to do it; but he would not differ from Lord Justice Cotton on that point. There was a little doubt as to whether it ought to be done quite so late, but he thought no conceivable injustice would be done; there were no merits in question, and it was a mere matter of form. There would, therefore, be no amendment, and as to costs he concurred in the decision of Lord Justice Cotton that those who really fought the plaintiffs should pay the costs.

The London Electric Supply Corporation (Limited) v. Roberts, jun.

In the Westminster County Court yesterday (Thursday) an action was brought by the London Electric Supply Corporation (Limited) against Mr. Roberts, jun., the professional billiard player, of 99, Regent-street West, to recover a sum of money for light supplied. The defendant put in a counter claim for damages, by reason of the failure of the light, consequent loss in his business, and also claimed £10 compensation for allowing the company to fix a pole on the roof of his premises for the purpose of carrying the wire. For the defence it was alleged that on several occasions the light failed, and gas had to be resorted to, and that in consequence of that the company had been given notice to discontinue the supply, but had failed to do so for some time afterwards. It was proved on behalf of the company that the pole on defendant's house was erected expressly for him, and was what was known as a terminal pole. The Judge found for the plaintiffs on the claim, and for the defendant on the counter claim for £5. 10s.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February 9th*, 1889.

A very interesting idea of the amount of inventive work being done in the field of electricity is furnished by the summary which is contributed this month to the New York *Electrcal Engineer* by Mr. T. D. Lockwood of the patents on electrical and related inventions issued from the Patent Office during 1888. It appears that the number of such patents is no less than 1,503, or 7·67 per cent. of the total number of 19,585 patents of all classes. Of the electrical patents no fewer than 365 relate to arc lamps, incandescent lamps, fixtures, motors, and methods of distribution for light and power. Supplementary to this class are 347 patents relating to primary and secondary batteries, dynamos, magneto machines, dynamo regulators, governors, and instruments of measurement, &c. The old class of telegraphs includes only 64 patents, but in electric signalling there were 185, and in telephony no fewer than 202. These figures go to show that the two fields being most actively developed at the present time are those of telephony and the utilisation of heavy currents. The indications are that the present year will show no falling off from the large total above given, but that in all probability it will be exceeded. It is to be noted that no fewer than 137 patents related directly to electric rail ways and motors for that work, and the present extreme activity in this field is calculated not only to greatly increase those figures, but to create a number of subordinate classes of considerable extent. There is at present no sign of decrease in the creative and adaptive power of our leading inventors. Thus it is said, for example, that Mr. Edison alone has some 200 or 300 applications now filed in the patent office, and I have occasion to know that the attorneys of other well-known electricians are also as busy as they can be.

A great many of our American inventions and ideas have already been welcomed abroad, and the figures that I have given above go to show that a great many more will soon be offered for exploitation in Europe as well as here. It seems likely that attention will be drawn to the development of electricity in America by the exhibits that will be made at the approaching International Exposition at Paris. There is every promise that, no matter what may be the show in other departments, America will be at least well represented so far as electricity is concerned. It is currently reported that Mr. Edison will spend from £8,000 to £10,000 on his personal exhibit, all his inventions being grouped together in a space of 8,000 square feet in the machinery hall. This exhibit will not only trace Mr. Edison's evolution as an inventor, but will also illustrate the development of his inventions on a commercial basis. I hear that very elaborate preparations are now going on for this exhibit at the Edison laboratory, Orange, New Jersey, where Mr. W. J. Hammer, who is noted for his success in this direction, has been entrusted with full charge of the work. I also hear that there will be a very interesting personal exhibit made by Prof. Elihu Thomson, who has also been fertile in the development of electricity in a number of directions. The list of exhibits also includes a number of new motors, telegraph systems, &c., and it may be taken for granted that American dynamos and lamps will do no small part of the lighting which is expected to be such a feature of the exhibition every night. The exhibition proves a very attractive "card" for all our transatlantic steamship lines. It is already practically impossible to secure accommodation from this side to Europe during the early summer months. I think I mentioned already that a goodly number of our electricians and electrical engineers will be going over, and they may be expected not only to take charge of

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various big installations, but to participate in the electrical conference. They will also be joined by large numbers of our civil, mechanical and mining engineers. It is said that the rush for berths on the steamer which was to be set aside for the combined excursion of the engineers has already been so great that it will be necessary to run another special steamer from Philadelphia, and even then there will not be by any means room enough.

Some little attention is being directed just now to plans for utilising the enormous waste water-power of Niagara. I do not know whether English engineers take much interest in the subject, but as they are not averse to big projects I presume they have given the matter some little consideration, and, if I am not mistaken, Sir William Thomson himself has discussed it seriously. Your readers will doubtless be interested to hear that a very ingenious project, which is described in the *Electrical World* this week, has just been suggested by Mr. S. H. Hamilton, of Washington. It can be readily believed that no project would be tolerated for a minute that involved the construction of any kind of works in front of the Falls, where they would be in full view of the spectators, and would be a blot on the magnificent scenery. Of this class was one scheme which was widely discussed in the papers not long ago, which proposed to moor a string of barges right across the lip of the fall so that their wheels at the stern would operate flexible shafting and transmit power by that means to machinery on shore. The only project that up to the present time has amounted to anything is that by which some 5,000 horse-power is now used in the American town of Niagara Falls by means of a canal which takes in the water above the upper rapids, and which discharges itself just below the passenger suspension bridge which was wrecked by storm the other day. This canal is, of course, in no way detrimental to the scenery, and it has therefore been proposed to enlarge and extend it. The Hamilton scheme is of a quite different type, and proposes going in behind the Falls, back of the water as it precipitates itself into the basin below, and there in chambers excavated from the rock, erecting vertical pipes which shall catch a large portion of the water on the inner side of each fall. As the water is estimated to be about 15ft. thick as it goes over the Falls, it will be seen that such pipes could be ranged along the inside of the Falls, and take into them a large quantity of water without giving any evidence whatever of their existence. Mr. Hamilton proposes to utilise the power obtained from turbines at the base of the pipes, in driving shafting to which are belted dynamos, and the current from these dynamos is to be utilised not only in lighting and supplying power for manufacturing purposes in the immediate neighbourhood, but is to be transmitted 25 miles to Buffalo. Mr. Hamilton is in earnest about his scheme, and has already obtained estimates from leading companies and firms as to the cost of apparatus for the initial plant of 500 or 600 horse-power. He has already formed a company with a capital of $20,000,000, to raise funds for prosecuting the work, and is now moving in the New York State Legislature for permission to sink his shafts for the construction of the subterranean chamber in which the dynamo will operate. He believes that everybody who visited Niagara would also wish to visit the dynamo room and take lunch at the restaurant there, and probably he is not mistaken.

It is somewhat singular that the *Scientific American* this week also publishes and illustrates another scheme by a Mr. M. Maginn, a mechanical engineer, of Chicago. Mr. Maginn's proposition is to excavate a cavity or drift under the Falls, where the flow of water will be continuous. In this recess, which will accommodate various machinery, is to be placed a stationary iron truss designed to carry a travelling frame sufficiently heavy to support an overshot steel water wheel of 60ft. diameter, with shafting and spur gears and intermediate shafting and gearing connected up with dynamo machines. It is designed to place upon the travelling frame four mammoth dynamos of 25,000 horse-power each, and four smaller dynamos upon a suspended frame directly underneath. The travelling frame is to be moved in and out by means of a hydraulic cylinder, operated by a steam force pump on the river bank, in this way receiving more or less of the force of the water fall. The electric current generated in this way is to be distributed in the usual manner. Experts here are decidedly in favour of the Hamilton scheme as compared with that of Maginn.

PARIS NOTES.

(FROM OUR OWN CORRESPONDENT.)

PARIS, *February* 20, 1889.

If the work actually done only partly corresponds to that spoken of, it will not be long before Paris takes the lead in public and private electric lighting. Mr. Popp alone, interviewed by reporters of the *Figaro* and *Petit Journal*, has declared that he is erecting a steam station of 12,000 horse-power, which will be ready to work in a few months, independently of the other stations necessary for the distribution of the current to 150,000 incandescent lamps, which will be ready before two years. M. Popp added that he was preparing a plant for lighting with arc lights the whole line of the Boulevards, the Avenue de l'Opéra, Rue de la Paix, Rue Royale, &c., and hoped to start this lighting on the day of the opening of the Universal Exhibition of May next. I am afraid that Mr. Popp takes as already done what he wishes to be done, and that the list of the streets lighted by that time will suffer a large reduction. However, great efforts are being made in every quarter, and if all that is wished is not accomplished in the time promised, there is no doubt that before long Paris will become, in fact, the "Ville Lumière."

The Palais Royal Station increases its number of lights every week. At present there are no less than 3,000 lamps at work. The station has been fitted up for feeding 10,000, and this number will be certainly attained by the end of the current year. Meanwhile, pending the time when the mains from the central stations recently voted will be ready to distribute current, private installations are rapidly being fitted up. The Gare St. Lazare, with a plant for lighting the station with 150 Cance arc lights, and the Terminus Hotel, with 2,000 16 candle-power incandescent lamps, may be mentioned as some of the largest. I may add that there is a talk of lighting the Chamber of Deputies by electricity, and of extending the electric lighting of the Salle des Séances of the Senate at the Palais du Luxembourg to other parts of the building. The town of Cambrai is also discussing the question of the introduction of the electric light.

The late snowstorms have been very prejudicial to the working of the telegraph lines in France; three wires on the Paris-Marseilles line are in an unworkable state, the lines to Nimes and Montpellier are mixed together, the lines between Paris and Montpellier, Nimes, Avignon, Toulon, Cannes, and Agen are interrupted, and the same with the lines to the Bourbonnais. It is to be hoped that these accidents will serve as a lesson to the Postal Telegraph Department, and that all the telegraphic wires will be quickly laid underground. I have to announce a great fall in the prices of the shares of the Société des Métaux, and it is to be hoped that it will coincide with a reduction in the prices of the copper.

NOTES FROM BRUSSELS.

(FROM OUR CORRESPONDENT.)

BRUSSELS, *February* 18, 1889.

The Brussels municipality has already received several proposals with regard to the electric lighting of the centre of the town. M. Humbert, Belgian representative of the Thomson-Houston Company of America, has offered to light the Boulevard Anspach and the Boulevard du Nord for nothing, on the condition that the town authorities allow him to run overhead wires to the large buildings around the Bourse. The Thomson-Houston Company propose to establish a central lighting station in an outhouse belonging to the Van Volscerm brewery, which is close to the Grands Magasins Thierry. In addition to this station two more are contemplated; one in the Rue des Bouchers and the other in the Rue Royale. The object of the former station is to light the Galeries St. Hubert and other buildings in this district. This neighbourhood has also been well canvassed by M. Thierboom, who received considerable support. At the very moment, however, when this gentleman was about to instal his engines and boilers, the authorities raised objections owing to the proper permission not having been obtained. The Thomson-Houston people have now taken the matter up, and want to erect their plant in the buildings belonging to the old Salle des Ventes. M. Thierboom, however, is once more in the field, and this time with capital at his command, so that the Thomson-Houston Company will not have it all their own way. The third station contemplated by this company will be situated in some outbuildings belonging to the Banque Delloye et Cie., and it is intended to supply current to the big banking establishments in the Rue Royale and to the Théâtre du Parc. It is very improbable that the authorities will entertain these proposals, as they know very well what

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value is to be attached to all offers of gratuitous lighting. Moreover, the city engineer, who has been several times to Germany to study the question of central station lighting on the spot, does not conceal his preference for the system adopted by a certain powerful firm in that country.

The Lalaing electric light mast, intended for the square of the Nord-Est Quartier, will shortly be erected. The Government made a present of this mast to the town of Brussels, and promised to pay half the costs. In spite of this assistance the share of the town for hydraulic motors, dynamos, lamps, leads, &c., amounted to 40,000fr.. The authorities were opposed to this outlay, and contemplated returning this white elephant to the Government, when M. Lalaing came to the rescue, and reduced the share of the town to 20,000fr. This comparatively modest sum will doubtless be voted by the Finance Committee.

At Liége the electric lighting question is again to the fore. M. Tudor, of accumulator fame, has laid a proposal before the authorities for the lighting of the interior of the Hotel de Ville, as well as the steps of the Place du Marché. Accumulators will, of course, be used, and a preliminary trial at M. Tudor's expense is offered. If the scheme is carried out, it will not be the first of its kind, in Belgium at any rate. The commune of Dolhrain has about 100 incandescent lamps, which are run off Tudor accumulators, and which cost 2·5 centimes per lamp per hour, hydraulic power being used.

Some little time ago attempts were made to introduce the Schanschieff battery into this country. In spite of the eulogistic report of two English *savants*, the performance of this battery was by no means brilliant. A proposal was made to one of our leading manufacturers to buy the Schanschieff patents, which are at present owned by an English firm. The offer was, however, declined, and this little transaction has been indefinitely postponed. The report of the Railway and Postal Telegraph Department shows that the electric light is daily coming more and more into vogue in this direction. In 1883 the electric light used only amounted to 6,310 carcels (60,000 candles); in 1887 this figure was almost doubled. The light is, in fact, coming into general use at our large railway stations.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *February* 16, 1889.

The death of the Crown Prince has robbed the Vienna Electro-Technical Society of its patron. Of all the great men in the State none took such an interest in the development of this new science as the Crown Prince. He had been chairman of the Electrical Exhibition in Vienna, and was ever ready to aid and support any movement which had for its object the furtherance of electrical science. To him is due the saying, which has gained much currency, "that soon he hoped to see Vienna at night flooded with light." Hopes are entertained that the Archduke Rainer may be induced to take the lamented Crown Prince's place.

Compared with other countries, there is comparatively little activity in electrical matters in Austria. Apart from the company which is now being promoted by Messrs. Ganz and Co. and the Union Bank, for the purpose of lighting up a part of Vienna, another company is said to be in a fair way of being promoted, with a capital of 2,000,000fl., by Messrs. Siemens and Co., for the same purpose. It is, however, to be feared that the obstructive policy of the Vienna Town Council, may make the success of these two companies very questionable. In telephone matters greater activity prevails. The Vienna Company are connecting up at the rate of 50 to 60 a month. In the other towns worked by the Telephone Company of Austria new subscribers are joining rapidly, and the telegram transmitting service is being used more and more. Trunk lines are being run by the Government. The Vienna-Prague line is now taken in hand seriously, all preliminary work has been done, and the building is to commence in May. The Hungarian Government has also agreed to the connection of Vienna with Pesth, and this line is also to be built this year. In Bohemia eight trunk lines are to be finished, and the Government propose opening new exchanges in Dux, Brux, Aussig Teplitz, and Franzensbad, also in Salzburg.

Mexican Telegraph (Cable) Company.—Advices from the City of Mexico give the following statement for the year ended December 31 last (the last quarter partly estimated):—

	1888.	1887.	Inc. or Dec.
Earnings..	$318,080	$268,166	+$49,914
Expenses..	59,587	58,896	+ 691
Net	$258,493	$209,270	+$49,223

It will be seen that the operating expenses last year were little less than 19 per cent., as against about 22 per cent. in 1887.

CORRESPONDENCE.

TESTING INSULATION RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your leaderette on this subject in *The Electrician* of February 8th, in which you say:—"Now, apart from the practical inconvenience (amounting, in fact, almost to an impossibility) of bringing the mirror galvanometer into regular use for such a purpose, we are of opinion that the only really valuable test would be one with an E.M.F. considerably higher than that which the insulation will afterwards be subjected to, and, more than this, the current should be kept on the wire for some considerable time." Further, you remark in *The Electrician* of February 15th that I raise the objection that such treatment has a tendency to "break down" an incipient fault. Now, this last remark shows that you have misunderstood me, for I *fully agree with you* that it would be most advisable that every electric light and power installation *before* being accepted or taken off the contractor's hands should be stressed for some considerable time by an E.M.F. not less than the ordinary working E.M.F., and, if possible, with double the normal E.M.F., for the very purpose of developing or breaking down incipient faults, just as boilers and steam pipes are stressed to double their working pressure. Wherein I apparently differ from you is this, that I do *not* consider that it is absolutely necessary, or even advisable, to place delicate accurate testing instruments in direct circuit with these severe stress-ferreting currents. I much prefer to apply the stress current (where possible) by itself, and then *immediately* afterwards test the circuits with my delicate mirror galvanometer, and only an E.M.F. of 10 or 12 volts. I have used nothing else than a Thomson's mirror testing galvanometer, made up for me by White, of Glasgow, to a pattern which I devised when in the Eastern Telegraph Company, as handy for taking from the cable ships to shore in any boat and in any weather, and setting up in any place where a lamp can be got to burn. The little case 15in. high, 7in. wide and broad, contains a galvanometer with three coils, 1,000 ω, 1 ω and ·1 ω, controlling magnet and shunt box, key, lamp and scale complete. It can be set up within five minutes, and packed together in two minutes. By simply turning the mirror tube through 90 degrees, the very delicate cocoon silk suspension is entirely freed from the weight of the mirror, and then the whole apparatus can be handled like an ordinary handbag. I have used it in hundreds of instances, and in some of the most out landish and awkward places, such as stoke-holes, engine rooms, and cabins of ships, cellars, half finished houses and churches (for testing lightning protectors). With one meghom in circuit and one cell it gives a readable deflection. But if such an instrument be objected to for "regular use," anyone can procure the very compact and well-designed electric light lead testing set made by the I. R. and G. P. Company, Silvertown, which measures from ·01 ω up to 9 Ω, wherein the galvanometer consists of a delicate horizontal pivoted needle.

If we were under the necessity of placing in the hands of jointers or assistant electricians a battery of 100 or 200 volts, or a small portable dynamo capable of giving those E.M.F.s *along with* a reliable Wheatstone bridge, resistance coils, and a sufficiently sensitive galvanometer, we should find the apparatus very frequently out of order from fused coils, &c., and then it would soon be considered as a theoretical nuisance.

The application of high E.M.F.s are only necessary for the purpose of "breaking down" or developing an incipient fault. The mere detection of, as well as the position of, a fault can be best ascertained by a comparatively low E.M.F., and a sensitive galvanometer—say, one that will indicate the presence of $\frac{1}{1000000}$th of an ampere—with a few small cells contained in a portable case. Such apparatus is within the reach of and should be used by every one in charge of wiring, or by those who have to test and pass installations. No installation should be passed until tests with such apparatus have been taken *after* the working current has been kept on for some days.

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Referring to Dr. Waltenhofen's tests of the Vienna Court Theatre, you remark "that the results obtained show a higher constant (K somewhat exceeding 20,000) than any figure which has yet been proposed." My constant, you will remember, is K = 100,000 per lamp, or, say, = 50,000 for every lamp requiring 0·5 ampere, the average current per lamp of the incandescent lamp circuits, as stated by Dr. Waltenhofen. It is curious to note how foreigners bring out well-known British methods of tests and rules under their own names, *e.g.*, the "Uppenborn method" and the "Ross formula." The former is very old, and the latter is simply the rule of the Society of Telegraph-Engineers with the constant doubled. You will have observed that Dr. Waltenhofen tested the various sections with *but* 12 Siemens cells, or, say, 12 or 13 volts, and finally the whole with a 52-cell accumulator battery of, say, 110 volts. He very sensibly, however, avoided putting his Weinholt mirror galvanometer into direct circuit with this higher E.M.F. and the leading wires. His tests have evidently been taken with great care, although with an apparently unnecessary amount of trouble and detail. His description reads as if this job had been his first lesson and rehearsal of insulation resistance testing.

The high average results obtained for such a large installation of 5,300 lamps, and the extraordinary patience and perseverance exhibited by the testers are extremely creditable to both contractors and electricians, and materially add to the stock of knowledge on this most important subject.—Yours, &c.,

ANDREW JAMIESON.

[We are not conscious of having made the suggestion—which our correspondent very properly deprecates—as to putting a mirror galvanometer in circuit with a high E.M.F. As a matter of fact, we said, in so many words, "in this case the galvanometer need not be very sensitive." Our correspondent is, of course, right about the constant.—ED. *E.*]

"PRACTICAL ELECTRICAL MEASUREMENT."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The reviewer of this book is under a misapprehension when he speaks (*The Electrician*, February 15th, page 428) of an error inherent in ohmmeters, viz., the effect of the resistance of the current coil or of the current taken by the pressure coil.

Will you allow me to point out that the scale of an ohmmeter is, or ought to be, started from a zero obtained by coupling the pressure coil in shunt to the current coil alone, and there is therefore no such error as the reviewer imagines. This being so, I have to confess that the "ingenious method of winding" which he very kindly attributes to me is also mythical.—Yours, &c.,

SYDNEY EVERSHED.

THE EFFECTS OF CURRENTS UPON CONDUCTORS; AND THE "MŒNNICH INDICATOR."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Bartlett's letter in your issue of last week draws attention to a point of some little interest not only to the practical electrician but to the scientist. Those who have had much to do with resistances to carry heavy currents will agree with me, I think, in saying that there is an action something like the "fatigue of materials," even though the wire does not become sensibly heated. In my apprenticeship I well remember meeting with a set of resistance coils in circuit with a set of Brockie lamps, and on going to touch them they fell to pieces through brittleness; this, too, without having 'been habitually heated." German silver hardens on coiling into spirals, but the few experiments I had time to make in the beginning of last year seemed to show that it is only when that metal has been coiled in spirals or a helix that on passing a current through it for some time brittleness occurred. A straight wire carefully prepared and coupled up showed no signs of any such action, while a spiral of the same wire and under the action of the current for the same time became brittle. I think Mr. Preece drew attention to a somewhat similar action in copper wire, and he speaks of his difficulty in obtaining "virgin copper" through which one might be certain no current had been passed.

With regard to another matter in your issue of the 15th inst. It is curious how over and over again the same idea is repeated, or repeats itself, in similar forms. About eighteen months ago I had a similar arrangement to the "Mœnnich Indicator," as figured on page 438, at work in my laboratory in the North. I used it between a summer-house and the test room to indicate the changes in length of various materials inserted in the circuit of a battery which was at a distance. My attention had been drawn to this means of transmitting the relative position of a needle and scale; firstly, by a study of the Hughes induction balance, and then by the great attention paid at that time to mutual and self-induction. A scheme very like that shown was the outcome of several days' work at the question of how to transmit the position of the indicator outside to the laboratory, and on fitting up the arrangement it was found to work very well.—Yours, &c.,

CHARLES H. YEAMAN.

London, February 19.

HEMPEN-COVERED CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your Notes of last week's issue on "The Theory of Hempen-Covered Submarine Cables finding favour in America" you say: "There are various species of teredo which attack the cables, and some of these marine parasites have a special fancy for hemp."

I have had several years' experience in repairing cables, many of them in waters infested by various species of teredo, and I have yet to learn these borers have a "special fancy" for hemp.

Many cables have been attacked by the teredo, and the sheathing, composed of hemp or Manila with steel or iron wires, have been pierced into the core; but I do not think that is sufficient reason for saying these hempen-covered cables would suffer from the same cause.

During the repair of a cable I once took off two "stoppers," both secured to the cable a few fathoms apart; they had been "slipped" at the final splice years before; one was Manila, the other hemp. The former was riddled with teredo, the latter was nearly as good as the day it was "slipped." The teredo had not pierced it. Evidently they had no "special fancy" for the hemp in that case.

Some of these hempen-covered cables have been lying in Halifax (N.S.) harbour in use for several years, and have not required repair, although the bottom is infested with the teredo. These cables have been lifted and examined several times, with the result that shows the teredo has not yet learnt to "fancy" them.—Yours, &c.,

W. R. LUGAR.

54, Ramsden-road, Balham, S.W., Feb. 18, 1889.

BOOKS, &c., RECEIVED.

"Berechnung Elektrischer Maschinen." By Ernst Heinrich Geist. (Munich: R. Oldenbourg.)

"Gleanings in Science." By Gerald Molloy, D.D., D.Sc. (London: Macmillan and Co.)

Belgian Official Statistics:—(1) "Annuaire Statistique, 1887." (2) "Opérations de la Caisse Générale d'Eparique et de Retraite en 1887." (3) "Tableau General du Commerce de la Belgique, 1887." (4) "Compte Rendu des Chemins de Fer, &c., en 1887."

"Practical and Useful Diary for 1889." (Thos. Fleming, Son and Co., Halifax.)

"Popular Lectures and Addresses." Vol. I. (*Nature* Series). By Sir William Thomson, LL.D., F.R.S. (London: Macmillan and Co.)

"Illustrated Catalogue and Price List." (Messrs. Drake and Gorham.)

Supplement to Carpmael's "Patent Laws of the World." Edited by a Committee of Fellows of the Institute of Patent Agents. (London: William Clowes and Sons).

"The Elementary Principles of Electric Lighting." By Alan A. Campbell Swinton. Second edition, enlarged and revised. (London: Crosby Lockwood and Son).

"Notice Sur le Concours 49, Électricité." (Brussels, 1889).

"Laxton's Price Book for 1889." (London: Kelly and Co.).

"The Voltaic Accumulator." By Émile Reynier. Translated from the French by J. A. Berly, C.E., A.I.E.E. (London: E. and F. N. Spon.)

"Les Compteurs d'Energy Électrique." By E. Hospitalier. (Paris: G. Masson.)

"The Model Engineer's Handy Book." By PAUL N. HASLUCK, A.I.M.E. (London: Crosby Lockwood and Son.)

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

January 28, 1889.

1,500. R. M. Presland (London) and E. H. Glover (Walthamstow). Applying electric light to cycles.
1,510. W. M. Mordey. London. Improvements in electrical transformers.
1,535. J. A. Timmis. London. Improvements in the construction and working of dynamos.
1,537. A. J. Boult. London. Improvements in or relating to electric incandescent lighting (S. Doubrava, Austria).

January 29, 1889.

1,573. C. U. Fisher. London. Certain improvements in electro-magnetic transmitters (port electrics) (J. T. Williams, United States).
1,611. M. W. Dewey. London. Improvements relating to multiplex electric telegraphy.

January 30, 1889.

1,673. G. Philippart. London. Improvements in the construction of secondary batteries.
1,677. G. H. Whittingham. London. An automatic electric switch.

January 31, 1889.

1,757. J. Mason. London. A new or improved automatic coin-freed machine for giving electric shocks.
1,768. P. Von Hertling. London. Automatic circuit changer for electric currents.
1,775. M. R. Ward. London. Means and appliances for holding electric accumulators on vehicles.

February 1, 1889.

1,823. A. Coleman and H. F. Jackson. London. Improvements constituting a combined translator and indicator for telephonic purposes, part of such improvements being applicable also, either in such combination or otherwise, for preventing or lessening induction between translators placed near together.
1,827. M. Salmony. London. Improvements in telephones.
1,839. C. Wells. London. A combination electric arc light.
1,846. W. Boggett. London. Improvements in the application of heat produced from liquid hydro-carbon and water burners to the production of light and electricity, and in apparatus for this purpose.
1,850. W. T. Goolden and H. W. Ravenshaw. London. Improvements in the method of constructing the armatures of dynamo-electric generators and motors.

February 2, 1889.

1,855. H. Hobson, S. Rushton and A. Wood. Manchester. An improvement in insulators and appliances for fixing, tightening and retaining telegraph wires, electric wires, and other wires or ropes.
1,861. W. J. S. Barber-Starkey. Manchester. Improvements in and connected with galvanic batteries.
1,865. J. Bushell and G. W. Hughes. Liverpool. Improvements in telephone apparatus to be designated as a telephone receiver rest.
1,892. A. J. Boult. London. Improvements in electric motors and means for regulating the same (L. W. Serrell and H. L. Lufkin, United States).
1,903. S. Ziani de Ferranti. London. Improvements in electric motors and electric meters.
1,904. S. Ziani de Ferranti and F. Ince. London Improvements in dynamos suitable especially for use as motors.

February 4, 1889

1,856. J. H. Woodward, E. S. G. Rees. Manchester. Improvements in the method of and means for the regulation of dynamos.
1,961. R. H. Courtenay. London. Improvements in microphone apparatus for increasing and transmitting sounds by means of earth currents, also by means of chemical batteries.
2,003. A. L. Shephard. London. Improvements in electric regulating apparatus for use in connection with steam engines and other motors and dynamo electric machines.
2,006. H. H. Lake. London. Improvements in apparatus for receiving payments and permitting the administration of electricity in exchange therefor (D. R. Johnston, Belgium).

February 5, 1889.

2,044. C. H. W. Stielow. London. An improved type-writer and telegraphic apparatus applicable in combination therewith.
2,056. R. Wellens. London. Improvements in electric stop valves.
2,066. L. Paget. London. Improvements in the manufacture of electrodes for secondary batteries or accumulators.
2,071. A. B. Ferdinand. London. Improvements in electric systems.
2,079. A. H. Norman. London. An improvement in plates for secondary voltaic batteries.
2,080. H. H. Lake. London. Improvements in and relating to portable electric batteries and in electrodes therefor (L. T. Stanley, United States).
2,082. W. P. Thompson. Liverpool. Improvements in or relating to telephone call-boxes (A. Griffith, H. A. Burbank and W. H. Jordan, United States).

February 6, 1889.

2,137. E. Gwosdeff. London. Improvements relating to magnetic telephony.
2,141. C. Baur. London. An electric meter.
2,145. W. Green. London. An improved electrical apparatus for lighting cigars or pipes, and for other purposes.
2,151. W. J. Woodward and F. H. Judson. London. Improvements relating to electric batteries.

February 7, 1889.

2,168. W. P. Thompson. Liverpool. Improvements in or appertaining to electric meters (H. O. Tudor, Luxemburg).
2,169. W. P. Thompson. Liverpool. Improvements in or relating to electric signalling apparatus for railways (E. J. Jérome de Baillehache, France).
2,176. F. L. Rawson. London. Improvements in materials and methods of preparing the same for bases of electrical instruments and for other electrical purposes.
2,199. A. Douglas and F. Smith. London. Improved electric periodical contact-making switch.
2,231. C. Adams-Randall and W. H. Cook. London. Electric fog and danger signalling apparatus for railways.

February 8, 1889.

2,243. W. Andrews. Nottingham. Electrical connections attached to railway locomotives and to connect to a metal plate affixed near the rail, arranged by a metal wire brush.
2,276. E. Guitton. London. Improvements in the construction and arrangement of primary batteries (M. Sappey, France).
2,297. C. Smith. London. Improvements in primary and secondary transportable galvanic dry elements (W. L. F. Hellesen, Denmark).
2,299. L. A. W. Desruelles and R. F. O. Chauvin. London. Improvements in apparatus for measuring electric currents.

February 9, 1889.

2,313. H. N. Lawrence. London. Improvements in means of applying electricity for therapeutic purposes.
2,331. W. H. Dowland and W. Mills. London. An improved apparatus for economically effecting the double decomposition of certain substances by the aid of electricity.
2,349. T. H. White. London. Improvements in and relating to electric appliances for illuminating the dials of electric clocks and watches.

February 11, 1889.

2,375. S. B. Wilkins. Edinburgh. Improvements in the construction of telephones.
2,406. J. Roper. Huddersfield. Improvements in the mechanism of electric arc lamps.
2,407. A. Bernstein. London. Improvements in dynamo electric machines.
2,413. J. E. Wright and J. Moore. London. Improvements in printing telegraphs.

February 12, 1889.

2,472. W. L. Wise. London. Improvements in secondary batteries and plates or elements therefor (The Gibson Electric Co. of Europe, France).
2,476. S. Sudworth. London. An improved electrical alarm.
2,480. H. H. Lake. London. Improvements in and relating to apparatus for measuring electric currents (H. H. Cutler, United States).

February 13, 1889.

2,536. T. W. Watson and A. H. Watson. London. Lighting cigars, pipes, &c., by electricity.
2,544. A. Douglass and F. Smith. London. Improvements in the form and manufacture of secondary battery frames and plates.
2,567. P. B. Elwell and J. K. Starley. London. Improved means and apparatus for electrically driving vehicles.

February 14, 1889.

2,614. J. Oulton and J. Edmondson. Halifax. Improvements in electric meters.
2,628. M. Stuhl, J. M. Lautensläger and F. Lautensläger. London. Improvements in electric contact and alarm thermometers.
2,642. G. Forbes. London. Improvements in dynamo electric machines.
2,646. W. H. Scott and L. Paris and Scott. London. Improvements in apparatus or means for metering electric currents.

February 15, 1889.

2,674. H. J. Peddie. Edinburgh. Apparatus for signalling in mines and coal pits, and on railways and elsewhere, and for stopping the winding or hauling steam engines when such signals are given, and for causing intermittent currents of electricity or magnetism for any required purpose.
2,694. W. S. Goolden and S. Evershed. London. Improvements in apparatus for the measurement of electrical resistances.

SPECIFICATIONS PUBLISHED.

Week Ended February 13, 1889.

1888.

609. Berghausen. Determining poles of electrical circuits, &c. (Price 8d.)
3,590. Statter. Electrical transformers. (Price 8d.)
3,710. Tweeddale. Electro-magnetic motors. (Price 8d.)
3,841. Laurie. Telephonic apparatus. (Price 8d.)
4,940. Parker. Dynamo electric machines. (Price 8d.)
13,778. Vail and Seely. Telephone apparatus. (Price 11d.)
15,252. Madden and Madden. Battery plates. (Price 8d.)
17,340. Justice (Smith). Electro depositing cells. (Price 8d.)
17,535. Davis. Electrically operated domestic apparatus. (Price 8d.)
17,645. Currie. Secondary batteries. (Price 8d.)

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Amended Specification.

3,369,* 1881. HEDGES. Electric lighting. (Price 8d.)

WEEK ENDED FEBRUARY 20, 1889.

1888.

925. LORRAIN. Electric measuring, &c., apparatus. (Price 1s. 8d.)
1,386. FOWLER. Telegraph insulators. (Price 8d.)
3,981. HOPKINSON. Driving electrically propelled vehicles. (Price 8d.)
4,489. LAUCKERT and HAENSEL. Holders for electrical glow lamps. (Price 8d.)
4,593. RAWSON and WHITE. Electrical batteries. (Price 8d.)
5,233. WALTON. Fusible cut-outs for electrical circuits. (Price 8d.)
6,400. DINGLE. Electrical signalling apparatus. (Price 8d.)
7,696. COAD. Portable incandescent electric safety lamp. (Price 8d.)
18,057. JUSTICE (HEISLER). Electric lamps. (Price 8d.)
18,715. SMITH. Telephones, &c. (Price 6d.)
18,900. DEWEY. Electric telegraphy. (Price 8d.)

Amended Specifications.

4,628,* 1890. HIGGINS. Step type printing telegraphs. (Price 8d.)
7,530,* 1887. STATTER. Electrical transformers. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Submarine Telegraph Company (Limited).

Report of the Directors to be submitted at the meeting of the proprietors of this Company, to be held at the Offices of the Company, 2, Throgmorton-avenue, London-wall, E.C., on Tuesday, the 26th inst., at one o'clock :—

The accounts for the six months ended 31st December, 1888, show a net sum which enables the Directors to add the usual proportion of the receipts to the reserve fund, to recommend a dividend for the half year at the rate of 16 per cent. per annum, and to carry over a balance of £628. 19s. 3d. The dividend paid for the corresponding period of 1887 was at the rate of 15½ per cent. per annum.

The number of messages transmitted during the six months was 1,846,002 containing 20,328,271 words. In 1887 there were transmitted 1,695,860 messages containing 18,701,557 words. The average length of messages in 1888 was 11·01 words against 11·03 words in 1887.

The receipts of the half-year show an increase of £3,886. 13s. 4½d. over those of 1887, and the expenses show an increase of £1,283. 6s. 6d. This increase is principally caused by the insertion of much new cable when repairing several of the cables interrupted in the half-year, and by the thorough overhaul and repair of the steamer in the first six months of 1888, to which reference was made in the last report of the Directors. The proprietors were then informed that only £500 of the cost was charged in the accounts for June, 1888, and that the balance, £407. 14s. 9d. would be charged in the accounts of the present half-year.

The proprietors are no doubt aware that the Company's concessions and agreements with the Postmaster-General and with the foreign Governments expired on the 12th January, 1889. The Directors have to report that the respective Governments agreed to allow the Company to continue working their own cables, as well as those belonging to Her Majesty's Government until 31st March, 1889.

No arrangement has yet been definitely arrived at between the Directors and the Government for the acquisition of the Company's property, but considerable progress has been made, and as the Government has decided to take over the property on the 1st April, the matter cannot be much longer delayed. The Directors would have been glad to submit for the consideration of this meeting definite terms of agreement with the Government, but at the date of this report they are unable to do so.

Telegraph Construction and Maintenance Company (Limited).

Report of the Directors to be submitted to the members at the twenty-fifth ordinary meeting to be held at the offices of the Company, 38, Old Broad-street, London, E.C., on Tuesday, the 26th inst., at one o'clock :—

2. The accounts for the year show a net profit of £82,580. 3s. 6d. after charging the interest on the debentures. To this sum must be added £50,436. 10s. 10d. brought forward from last year, making a total of £133,016. 14s. 4d. From this amount is deducted the interim dividend of 5 per cent., paid July 17th, 1888, amounting to £22,410, leaving £110,606. 14s. 4d. to be dealt with. Of this sum the Directors propose to distribute a dividend of £1. 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2. 8s. per share, or 20 per cent., free of income tax, leaving £43,376. 14s. 4d. to be carried forward to the next account.

3. During the past year the cable factories at Greenwich and the gutta-percha department at Wharf Road have been fairly employed. A length of about 6,000 miles of telegraph wire has been insulated, including submarine and land lines.

The Company's steamships have laid cables between the Dutch Possessions in the Eastern Seas, and at the present time are engaged triplicating a portion of the Eastern Extension Telegraph Company's system to Australia.

Various repairs have been made in cables in the North Sea and in the Brazilian line between Madeira and St. Vincent ; and the Direct United States Company's Atlantic Cable has been placed in good working condition, repairs having been effected at a maximum depth of 2,200 fathoms.

4. The charter of the steamship "Kangaroo" to the Italian Government for distilling purposes in the Red Sea continued up to the end of May, and the Company have since disposed of her.

The steamship "Calabria" has been on charter since November last.

5. The Company's works at East Greenwich and Wharf Road are in efficient working order.

6. It is with regret that the Directors have to announce the death of their late colleague, Lord Alfred Paget. They have elected to fill his place Mr. William Shuter, who has held an important and responsible position in the Company since its formation.

7. The £150,000 Six per Cent. Debentures have been replaced by the issue of a like amount, bearing interest at 5 per cent. for a period of five years from the 1st January, 1889.

8. The retiring Director is Mr. George William Campbell, who, being eligible, offers himself for re-election.

9. The meeting will have to appoint auditors for the ensuing year. Mr. John Gane (Messrs. Gane and Jackson) and Mr. James Glegg (Messrs. Quilter, Welton and Co.), who retire, offer themselves for re-election.

The Brighton and Hove Electric Light Company (Limited).

Report of the Directors to the fourth ordinary general meeting of the Company, to be held at the offices of the Company, Gloucester-road, Brighton, on Tuesday, February 26th next :—

1. The Directors have pleasure in submitting to the shareholders the report of the operations of the Company from the 1st January to the 31st December, 1888.

2. The capital account has during this period been augmented by the sum of £3,100, which has enabled the Company to increase the capacity of its plant and to extend and re-arrange the circuits. The profit and loss account, after writing off an ample sum for depreciation of plant (which has, however, been kept in thorough repair out of revenue), shows a balance of profit for the year of £532. 12s. 9d., which, with the balance brought

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ELECTRICAL MACHINERY
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forward from last year's accounts, makes the sum to the credit of profit and loss account £603. 0s. 8d., and the Directors recommend the following appropriation of it :—

Dividend of 5 per cent. per annum on the share capital	£574 11 10
Carried forward to next year's profit and loss account	28 8 10
	£603 0 8

3. There has been a steady increase in the Company's business during the past year. The mains belonging to the Company now extend a distance of *over twenty miles* ; reaching westward as far as King's Garden, Hove ; eastward as far as Belgrave Place, Kemp Town ; and northward as far as Hanover Crescent, Lewes Road.

4. At the beginning of the year, in deference to a very general request, the Company arranged to run the machinery day and night, and though this has added considerably to the cost of working, it has given great satisfaction to the customers.

5. With the view also of placing the electric light within the reach of an extended number of customers, the Company has adopted a sliding scale of charge, which gives the consumer the benefit of a considerable reduction in price. This reduction came into operation on the 1st of January this year.

6. During the past year the Company has almost entirely transformed its method of supply, and replaced the old multiple series system with the converter system, by means of which it is possible to turn off lamps singly, instead of in groups, as hitherto. These changes have largely increased the number of the Company's customers.

7. The exact nature of the improvement in the Company's business may be seen by the following statements :—(*a*) Lamps supplied from the Company's mains on December 31st, 1887, equivalent to 2,970 10 candle-power lamps ; December 31st, 1888, equivalent to 5,500 10 candle-power lamps. (*b*) Quantities of electricity supplied from the works during the past year, as compared with corresponding months of previous year :—

	Units supplied. 1887.	1888.	Percentage of increase.
January	5,960	7,533	43 per cent.
February	3,865	5,430	40 „
March	3,444	4,550	32 „
April	3,188	4,813	51 „
May	2,180	3,359	54 „
June	2,056	2,707	31 „
July	1,985	2,687	35 „
August	3,552	4,300	22 „
September	4,801	5,419	14 „
October	6,337	7,615	20 „
November	7,512	12,567	74 „
December	8,738	13,930	60 „
Totals for the 12 months	52,918	74,910	41 „

8. During the past year the Board of Trade have represented to the Company the advisability of applying for statutory powers, in order to enable it to change its method of distribution by means of overhead wires to a system of underground mains ; and in view of the increasing demands for the electric light in Brighton and Hove, and the necessity of laying cables underground in order to cope with a large business, the Company made application in November last for a Provisional Order under the Electric Lighting Acts, 1882 and 1888, and this Provisional Order is at present being considered by the Board of Trade.

9. The Company has given a pledge to the Brighton Corporation and the Hove Commissioners to largely increase its works in the event of the Provisional Order being granted, and the necessary formal meetings have been held to sanction the raising of the nominal capital of the Company from £25,000 to £100,000, and the change of the name of the Company from the Brighton Electric Light Company (Limited) to the Brighton and Hove Electric Light Company (Limited).

10. When the Directors deem the time opportune, the shareholders will be called together and consulted with regard to further plans for the extension of the Company's operations.

12. Mr. Arthur Wright, who has brought the works to their present state of efficiency, has continued to act as Managing Director ; and the thanks of the shareholders are due to him for the highly satisfactory manner in which he has conducted the business of the Company during the past year. He reports that the engines and dynamos have continued to give satisfaction, and are at the present time in thoroughly good working order.

13. During the past year, Mr. William Smithett, one of the Directors of the Company, has resigned his seat on the Board in consequence of his leaving Brighton, and his place has been filled up by Mr. Thomas Webber Jerrard. The Board has also been strengthened by the election of Mr. Philip Arderne Latham. The retiring Directors are Mr. Robert Hammond, Chairman, and Mr. Arthur Wright, Managing Director, who offer themselves for re-election.

14. The meeting will have to elect an auditor or auditors for the ensuing year.

NEW COMPANIES REGISTERED.

GRAPHOPHONE SYNDICATE (LIMITED).—This syndicate was registered on the 14th inst., with a capital of £100,000 in £10 shares, to acquire seven British patents taken out by Bell and Tainter, with application for others now pending, relating to the reproduction of sound, upon terms of two provisional agreements dated 31st ult., the first between Woodhouse and Rawson (Limited) and J. H. Ward, and the second between Walter T. Glover and Company and J. H. Ward ; and to carry on business as engineers and electricians. The subscribers, with one share each, are :—F. L. Rawson, 11, Queen Victoria-street, electrical engineer ; J. H. Ward, 55, Shelgate-road, Wandsworth ; J. C. St. Quentin, 38, Lee-road, S.E. ; J. McFarlan, Invermay, Wimbledon ; Sir R. W. Rawson, 68, Cornwall-gardens, W. ; Sir F. Leopold McClintock, 8, Atherstone-terrace, S.W. ; G. Offord, Putehill Villa, Sydenham. The subscribers are to appoint the first directors ; qualification, 100 shares ; the company in general meeting will determine remuneration.

MINES AND GENERAL TELPHER COMPANY (LIMITED).—This company was registered on the 15th inst., with a capital of £4,000, in £1 shares, to construct and work lines for the carriage of minerals and other materials, under a license from the United Electrical Engineering Company (Limited.)

SUNDERLAND AND DISTRICT ELECTRICITY SUPPLY COMPANY (LIMITED).—This company was registered on the 13th inst., with a capital of £100,000 in £5 shares, to generate, distribute, and supply electricity for lighting, heating, motive power and other purposes. The number of directors is not to be less than four, nor more than nine ; qualification, 100 ordinary shares, or £500 stock ; the subscribers are to appoint the first ; remuneration, £250 per annum, and one-tenth of the annual profits of each year (except the amount carried to reserve) over £7 per cent. per annum, provided that £1,000 per annum be the maximum remuneration.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this company for the week ended February 15 amounted to £5,346.

LONDON ELECTRIC SUPPLY CORPORATION.—The directors of the London Electric Supply Corporation (Limited) offer for subscription £250,000 preference capital, in 50,000 shares of £5 each. Under the resolutions creating these shares, holders have the option, on or before December 31, 1895, of converting their shares, when fully paid up, into ordinary shares of the corporation. The corporation was formed in August, 1887, to purchase the undertaking of Sir Coutts Lindsay and Co. (Limited), which company had for three years previously carried on an electric lighting business at the Grosvenor Gallery, New Bond-street, W., and to develop and extend the same. It is estimated that the net profit, after providing for depreciation, will amount to £60,000 per annum, upon which the interest on the preference shares now offered for subscription, amounting to £15,000 per annum, will be a first charge. The list of applications for shares closed at noon on Tuesday last.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 15th, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,506.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The receipts of this company for the half-month ended February 15 amounted to £3,046, as compared with £3,424 last year, being a decrease of £378.

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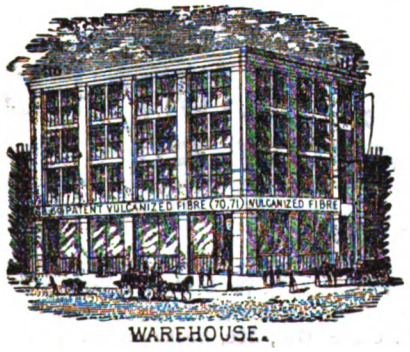

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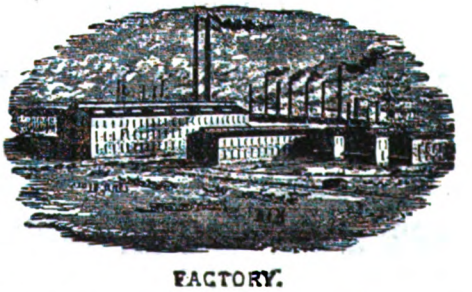
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Feb. 20, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Feb. 20, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	7/6	Anglo-American ..... xd	48⅛ 49½	3 5 8	Jan., Apr., July, Oct.	49¼	49
2,614,820	Stock	15/0	Do. Preferred ..... xd	82 83	3 18 4	,, ,,	83⅛	82¾
2,614,820	Stock	5/0	Do. Deferred	16¾ 17¼	...	February	17⅛	16¾
130,000	£10	3/0	Brazilian Submarine	13¾ 14	5 0 0	Mar., June, Oct., Dec.	14	13¾
112,900	£100	5%	Do. 5 per Cent. Bonds.....	101 103	4 17 1	January and July....	101	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine ..... xd	14 14½	6 4 2	February and August	14⅛	...
6,000	10	10/0	Do. Preference 10% ..... xd	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	3¾	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October ...	...	...
60,710	20	3/6	Direct United States	9⅝ 10⅛	3 19 0	Jan., Apr., July, Oct.	10⅛	9⅞
380,000	10	2/6	Eastern	13 13¼	4 10 7	,, ,,	13⅜	13
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	...	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock ...	106 108	3 14 1	May and November.	...	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	...	...
250,000	10	2/6	Eastern Extension	13 13¼	4 18 4	Jan., Apr., July, Oct.	13¼	13 1/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891.....	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct.(Austrln.Gov. Sub.) Debs. 1900 ...	102 104	4 16 2	January and July ...	...	...
179,177	10	1/3	Globe Telegraph and Trust	6⅞ 7⅛	5 1 9	Jan., Apr., July, Oct.	7 3/16	...
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14 9/16	14¼
150,000	10	5/0	Great Northern.....	14¾ 15¼	4 18 6	Jan., July, and April	15⅛	15
17,000	25	2/6	Indo-European.....	39 41	6 1 11	April and October ...	41	...
9,000	8	4/0	Reuter's	6⅞ 7	5 14 3	April and October ...	...	...
15,609	10	3/0	West African Telegraph.....	6½ 7½	...	...	7	...
300,000	100	5%	Do. 5 per Cent. Debentures	101 104	4 16 2	March & September	102	...
30,000	10	6/0	West Coast of America	9½ 10	...	January and July ...	9⅞	9½
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1½ 1⅝	...	...	1 1/16	1⅛
34,563	10	12/0*	Do. 1st Preference 6%	11⅞ 11⅝	...	April and October ...	11⅞	11⅝
4,669	10	+	Do. 6 per Cent. 2nd Preference..... ...	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	12⅞ 13⅛	5 14 3	March & September	13⅛	12⅞
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	11/16 13/16	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid).....	⅜ ½	2 14 11	... ...	...	...
80,000	5	5/0	United.....	14¾ 15	5 0 0	June and December	15 1/16	14¾
55,000	5	3/0	United River Plate.....	5½ 5⅝	...	January and July ...	5¾	5 1/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3 3½	...	...	3⅜	3⅛
23,692	5	2/0	Do. (fully paid)	3¾ 4¼	...	February & August	4⅜	4¼
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅞ 3⅛	...	...	3 1/16	2 7/16
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	5 9 3	March and July	43½	42¼
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works ...	18 19	5 5 3	February & August	18⅛	18

* Account arrears. † No dividend since May, 1880.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 563.—Vol. XXII. FRIDAY, MARCH 1, 1889. Price Fourpence.

NOTES.

At a special meeting of the Commissioners of Sewers, held on Tuesday last, the report of the Streets Committee on Electric Lighting, which appeared in our issue of February 8th, was finally adopted, and tenders will be invited forthwith on the basis of the conditions therein set forth. An amendment moved by Mr. C. T. Harris was, however, only rejected by a majority of one vote. Mr. Harris's proposal was to the effect that nothing should be done until certain Companies, which he proceeded to name, had obtained Provisional Orders for the City district. If this suggestion had been adopted, not only would it have entailed another long delay, but it is obvious that it would practically have put the Commissioners almost at the mercy of the Companies who had obtained Provisional Orders.

The following paragraph appeared in the *Financial News* of the 22nd ult. with reference to telegraphic communication with South Africa :—

> There has been no cable communication with Johannesburg for the past week, the line being out of order. This interruption of communication has not only caused serious annoyance in the South African markets, it has also led to a movement for laying a new cable. Some of the most influential men identified with the Witwatersrand district are behind it, and we learn that the capital has already been offered five times over.

In reply to the above Sir James Anderson writes to the *Financial News* as follows :—

> The Eastern and South African Telegraph Co.,
> 50, Old Broad-street, London, E.C.,
> 22nd February, 1889.
>
> Sir : In your issue of to-day I notice a paragraph to the effect that the cable communication to Johannesburg has been interrupted, and that this has led to a movement for laying a new cable.
>
> Will you permit me to say there has been no interruption of the cable communication whatever, neither have the South African land lines been interrupted as far as the Transvaal. The whole of the interruption, so far as we know here, has been within the Transvaal itself.
>
> The inconvenience of this interruption has been represented to the Transvaal Government in every possible way, and at present communication is again restored.
>
> Efforts are being made to improve the land service upon all the South African lines. I may also state the ships of the Telegraph Construction and Maintenance Company, and the India-Rubber, Gutta-Percha and Telegraph Works Company will sail from London on the 8th March next, to lay an alternate line on the West Coast down to the Cape of Good Hope direct.—Yours truly,
>
> (Signed) James Anderson, Managing Director.

As a sample of the unreasoning animus which some sections of the Press thoughtlessly throw into their remarks upon submarine cable companies, the paragraph from the *Financial News*, which we reprint above, is in its way quite unique. As a matter of fact, there is no cable to Johannesburg, which is a town in the extreme North of the Transvaal 350 miles inland from the cable terminus at Durban. The real cause of dissatisfaction is the inadequacy of the land line to meet the overwhelming pressure of traffic consequent upon the gold rush which has recently set in and the breakdown of many of the operators through overwork. Numbers of telegraph operators are, however, hastening to the Transvaal and Cape Colony, and additional lines are being erected. Until the service is reorganised, therefore, the public must submit with what patience it may to the inconvenience caused by delays and errors. The correspondent of the *Financial News* is evidently unaware of the above, as also of the fact, to which we further allude below, that an alternative line of cable communication to South Africa is on the point of being laid down. Perhaps, however, the oddest statement to which our contemporary commits itself is that the capital for a new cable has been subscribed five times over in the Witwatersrand district. Seeing that a cable such as is spoken of would cost three or four millions sterling, the district referred to must be a perfect El Dorado.

The report of the twenty-fifth annual meeting of the Telegraph Construction and Maintenance Company, published by us this week, furnishes a striking commentary on some recent complaints as to the dilatoriness of cable companies in supplying adequate means of communication with our Colonial Empire. The Telegraph Construction and Maintenance Company, besides effecting several important repairs and extensions, have within the past twelve months constructed and laid a 1,000-mile triplicate cable connecting Western Australia with Java, an operation the successful accomplishment of which was announced on Tuesday last. Another line of 456 miles has been submerged between Java and Moluccas. They have also already manufactured the greater portion of the 1,530 miles of cable required to complete the West African system, and a vessel will sail with it at the beginning of next week. When this operation has been carried out Africa—with the exception of the coast between Cape Town and Durban, which is provided with land lines—will then be surrounded by submarine cables on all sides, east and west, and on the Mediterranean.

On first hearing that Mr. Crompton had recommended the use of alternating transformers at Harrow, one is inclined to exclaim, "Is Saul also amongst the Prophets?" And on reading further the report of the meeting as it appears in the

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Harrow Gazette and one of our weekly contemporaries, it would, moreover, be natural to conclude that he had prophesied with all the characteristic enthusiasm of the new convert. A letter from Mr. CROMPTON, which will be found amongst our correspondence, puts, however, a different complexion on the affair. It will be seen that Mr. CROMPTON denies that his general preference for battery transformers has been shaken during the period which has elapsed since he read a Paper on the subject before the Telegraph-Engineers. In replying to the discussion on that Paper, moreover, he acknowledged that in certain districts the alternator might even possess a distinct advantage over the battery (see *The Electrician*, May 25, 1888, p. 89). Such a district he has found at Harrow.

MR. CROMPTON appears also to have been the victim of another misconception, although, unless the reports are again lamentably incomplete, he failed to set himself right upon this point, even when directly challenged to do so. In quoting a sum "not exceeding £6,000" as the cost of central station and distributing plant for the supply of 3,000 lamps, it is impossible to suppose that he could have referred to lamps of more than eight candle-power, and even then the estimate seems remarkably low. But when asked by an electrician present (Mr. W. F. TAYLOR) how the present quotation of £2 per lamp could be reconciled with the estimate of £5. 14s. per lamp [of 50 watts] in his Paper of April last, Mr. CROMPTON is reported to have said that the difference arose from the additional cost of laying underground mains in London as compared with the provinces. The explanation is so obviously inadequate that, whether Mr. CROMPTON did or did not content himself with it, we have no doubt in our own mind that the discrepancy arose in the way above suggested. The incident affords a pertinent illustration of the confusion arising from the use of the term "lamp" as a unit of power. We hope that Mr. PREECE's definition will be adopted that, unless otherwise specified, a "lamp" means a lamp of 50 watts.

FROM the report of the same meeting in the *Harrow Gazette* we quote the following passage, which will be read with some interest:—

> Mr. PITCAIRN: Is not the alternating system dangerous under any circumstances?
>
> Mr. CROMPTON: No; competition has given rise to the statement, but it is absolutely untrue.

Mr. CROMPTON was no doubt able to make this statement with a clear conscience, but coming from such a source the testimony will doubtless be valued by the advocates of the alternator.

AT the Physical Society on Saturday last Prof. AYRTON exhibited for the first time the long-promised low-reading voltmeter for commercial use. Next week we shall describe and illustrate the instrument in detail. Meanwhile, we may mention that the dial of the instrument reading up to 2·5 volts is about 6in. diameter, and is graduated in hundredths of a volt; the reading being proportionate right round the scale. To show the delicacy of the instrument, Prof. AYRTON made the simple experiment of taking the internal resistance of a secondary cell, by reading the volts (1) on open circuit, and (2) when a known current (of 10 amperes) was passing. The advantage of a trustworthy and portable instrument capable of taking accurate measurements of this class will be patent to every electrical engineer.

WE understand Prof. AYRTON will take an early opportunity (probably at the meeting of the Civil Engineers on Tuesday next), to give a preliminary account of the tests which have been carried out at the Central Institution on the Tesla Motor. On another page will be found a diagram of the windings of the motor, which is now published for the first time.

THE *Electrotechnische Rundschau* in a recent number discusses the "line of economical demarcation" between isolated lighting plant and central station service. It is, of course, obvious that the limit is a very variable one, depending not merely on the cost of power compared with the central station tariff, and upon the size of the installation and the hours of lighting, but chiefly upon the value set by the consumer on the trouble and possible nuisance of having machinery on his premises. At the same time the question is one which, in the case of large and important buildings, may be expected in future often to arise. Moreover, there are some consulting electricians who hold that in favourable circumstances the limit in point of size is arrived at much sooner than is usually supposed. Nevertheless, we do not believe that any one in this country will place the limit anything like as low as, according to the above authority, it stands in Germany. Our contemporary calculates the annual cost of a private installation of 50 lamps of 16 candles, worked by steam power, and burning 2,000 hours per annum, at £100, excluding interest on capital outlay. Taking the Central Station tariff at four pfennings (say ½d.) per lamp hour, and adding cost of lamp renewals, and rent of meter, the cost of 2,000 lamp-hours is £184. So that in Germany it appears that only installations of comparatively small size can afford a central station service.

THE evidence of Mr. C. F. BRUSH, taken on Commission in Cleveland, Ohio, in the action of King, Brown v. The Anglo-American Brush Company, will be found on another page.

THAT electricity might in some way be employed to hasten the process of tanning is one of those ideas which has been "in the air" for a long while. Amongst our "Scandinavian Notes" (*Electrician*, November 9th, 1888) will be found a reference to a method already in use in Sweden which is said to give results of the most satisfactory character. More recently we hear on very good authority that a process of the same kind now at work in Paris produces leather of excellent quality from the raw hide *in four days*. The importance of this new field for the application of electricity is too obvious to need comment.

THE electric motor has been put to many strange uses, from blacking boots to driving dentists' lathes, but we doubt if this

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long-suffering machine ever found itself in a more novel or more trying position than was recently the case at Toronto. We cannot do better than quote our correspondent, Mr. H. E. DOLAN'S, own words :—"I enclose a cutting from the *Empire* of Toronto, describing the use of the road for the first funeral on Sunday, 17th. On that occasion I drove a motor car, which towed another, both full, and although we were about 3¼ miles from the power station, and had four other cars close behind, all taking as much current as they could, I got my cars up the bridge incline at about 3½ miles per hour, without distressing the motor in the least." After this there is nothing left for us but to agree with the remark of the *Empire* of Toronto, that "a funeral *cortége* consisting in part of street cars driven by electric motors is somewhat of a novelty, even in this age of progress." We should mention that the funeral was that of an Oddfellow.

FOR child-like simplicity and infantile excitement the well-known babe who cried to "see the wheels go wound" is not in it in comparison with the London reporter of the *New York Herald* who took a trip last week on the electrical omnibus. For two columns and a-half he drivels on in this style :—"It spun down the Haymarket from its native lair in James-street like a barrel hoop down a toboggan shoot ; it whisked over the broad plazza of Trafalgar-square, and sped away like a summer zephyr in quest of Blackfriars-bridge. Then it took in the City, and brushed past the Mansion House like a stray comet on the war-path. . . . The voyage was a procession from beginning to end, a journey throughout whose tortuous length the 'bus was moving through a pageant of glory entirely of its own manufacture." MR. RADCLIFFE WARD may well pray for deliverance from his friends. Meanwhile, he may be congratulated on the immunity from serious accident with which his trips have hitherto been associated. It will, however, require a good many such excursions before he will be in a position to publish an authenticated statement of the economical results.

Melbourne Exhibition Award.—We are glad to learn that the Woodhouse and Rawson Electric Supply Company have received a "First Award" at the Melbourne Exhibition.

Rotherhithe Vestry.—At a meeting of this Vestry, last week, it was agreed to support the proposals of the London Electric Supply Corporation, subject to certain objections raised by the Vestry.

Galway.—It will be seen by our advertisement columns that the Galway Town Improvement Commissioners are inviting tenders for the public lighting of that town by gas or electricity.

St. Martin's-in-the-Fields Vestry.—At a special meeting of this Vestry, last week, a resolution was passed approving the application made by the London Electric Supply Corporation for a Provisional Order for this district.

The Hague.—The Hague Tramway Company have just obtained a concession from the Dutch Government for an electric tramway running between Schevening and the Hague. The current will be generated at a central station near Schevening.

Important Sale of Electrical Plant.—The important sale of dynamos, lamps, cables, and other electrical fittings, which we announced in our issue of February 15th, will take place on Wednesday, March 13th. Further particulars will be found in our advertisement columns.

Electric Tramway for Naples.—The *Bolletino delle Finanze* says that an Italian firm of engineers has made a proposal to the municipal authorities of Naples for the establishment of an electric tramway. The concession asked for comprises five lines, having an aggregate length of 14·7 kilometres.

The Lake District.—Steps are being taken to form an electric light company at Keswick, the project having the support of several influential residents. A survey has been made, and it is expected that motive power will be obtained from the River Greta. A prospectus will be issued to the public shortly.

Institution of Electrical Engineers, Students' Meeting.—A meeting was held on Friday, February 22nd, at 8 p.m., Mr. J. Rance, jun., A.I.E.E., in the chair. A Paper was read on "Ship Lighting and the Aspects of Electrical Industries in the Colonies," by Mr. H. W. Handcock, which occupied the whole evening. A discussion upon it will take place on Friday, March 8th.

St. George's (Southwark) Vestry.—The usual fortnightly meeting of this Vestry last week was made a special one for the purpose of considering the recommendation of the Roads Committee, "That this Vestry assent to the granting of a Provisional Order by the Board of Trade to the House-to-House Electric Lighting Company to supply electricity within the parish." The recommendation was carried unanimously.

Newcastle.—At a meeting of the Newcastle City Council on Wednesday in last week, the Town Improvement Committee presented their report relative to the applications for consent to Licenses to supply electricity in Newcastle. The committee recommend that the proposed Licenses of the Newcastle Electric Supply Company and of the Newcastle and District Electric Lighting Company should be supported. The report will be considered at a special meeting of the Council on March 6th.

Galway.—The secretary of the Galway Electric Company writes as follows :—"At a ball recently given by the Royal Welsh Fusiliers at the Courthouse, Galway, to commemorate the fall of Coomassie, we lit the entire suite of rooms by incandescent lamps, including ball room, supper and refreshment rooms, entrance hall, and ante room. The Courthouse was temporarily connected with our central station, which is now approaching completion, and part of which is already working."

The Electric Light in the Emperor's Palace at Pekin.—The Emperor of China intends to introduce the electric light into his palace, for which purpose an engineer from the firm of Siemens and Halske, of Berlin, recently arrived at Pekin with the necessary material. The installation was to be completed before the Imperial wedding, which has just taken place. The installation had to be erected and tried in another place in order to ascertain whether the electric light is not imbued with a "supernatural power."

Holborn Board of Works.—At a general meeting of the Holborn Board of Works on Monday evening last week, the Committee of Works reported that they had had under consideration applications from the London Electric Supply Corporation and the Metropolitan Electric Supply Company for permission to apply to the Board of Trade for Provisional Orders. They recommended that permission be granted the House-to-House Electric Company, who wrote asking for sanction to an application for a License. The application was granted.

Bath.—At a meeting of the Bath Town Council last week, the following resolution, proposed by Mr. Jolly, was carried *nem. con.* :—"That it is desirable in the interests of the public to have the electric lamps supplied by means of underground instead of overhead wires, and that it be referred to the Electric Lighting Committee to so far vary the present contract with Mr. Massingham as to supply the area by means of underground wires, at the price of £25. 17s. 6d. per annum per lamp, and to allow a period of twelve months instead of six months for the completion of the electric lighting, and such other alterations as may be necessary in the contract.

Madrid.—With the exception of the plant in the Italian Opera House (says *Industries*), the isolated electric light installations at the Madrid theatres are going on unsatisfac-

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torily. In consequence, fresh efforts are being made to establish a large central station in this city, and it appears that there is some chance of this being now carried out, as the local authorities are giving their assistance to the scheme. Major Cabanyes, of the Artillery, is to be entrusted with the technical management of the installation, which has been promoted by Belgian capitalists. No electrical details have yet been made known.

Indo-Persian Telegraphs.—Colonel Sir R. Murdoch Smith, Director of the Museum of Science and Art in Edinburgh, has laid before the Royal Scottish Geographical Society a history of the Indo-Persian Telegraphs, in the construction of which he played so important a part. He stated that, twenty-one years ago, when the overland wire for Indo-European messages was proposed (which was completed in 1870), the expectation was that a message would eventually be got through in a period not exceeding three days. At present the time occupied by a message from the United Kingdom to any part of India, from handing in to delivery, does not exceed an hour and a-half.

Strand District Board of Works.—At a meeting of this Board on Wednesday evening, last week, the Lighting Committee brought up a long report dealing with the proposals for the lighting of the district by electricity. The first portion of it dealt with applications on behalf of the Electrical Power Storage Company and Messrs. Coerber for consent to obtain Provisional Orders. Both of these the committee recommended should be refused. The committee, on the other hand, recommended that the seal of the Board should be affixed to the agreement with the Metropolitan Electric Supply Company. After a short discussion, the recommendations were agreed to unanimously.

Electric Lighting and the Indian Government.—The Government of India has issued a set of 49 rules to be observed in the erection of electric lighting installations. Objection may be taken to any part by anyone interested up to the 1st May. Speaking without special knowledge of local requirements, we should say that while there is little or nothing specifically objectionable in the rules taken individually, yet they are far too numerous and too detailed. Experience has shown that it is frequently impossible to comply with a cut-and-dried set of regulations which profess to order all the minutiæ of the work. It would be much better to lay down a few general rules and leave the rest to the fire insurance offices, with a general right of veto when good cause arises.

New Triplicate Java-Australian Cable.—It will be remembered that some time ago, on more than one occasion, owing in one instance to submarine volcanic action and in the other to the accidental interruption of one cable while the ship was grappling for the other, which was interrupted, Australia was cut off from telegraphic communication with the rest of the world. With great promptitude the directors of the Eastern Extension, Australasia, and China Telegraph Company (Limited) announced their intention to lay a third cable, avoiding the neighbourhood where volcanic action had been experienced. The company now announces that this cable between Java and Western Australia is completed, and that the line will be shortly opened for traffic. This will give the Australasian Colonies the advantage of a third cable to Java, and an alternative land system *vid* Perth to the overland line between Port Darwin and Adelaide, thus greatly adding to the security of telegraphic communication with Australasia.

Alternative Cable Communication to South Africa.—The ss. "Scotia," belonging to the Telegraph Construction and Maintenance Company, leaves the Thames on 3rd inst. for Cape Town, where she is expected to arrive on March 26, with the 1,530 miles of cable to be laid from Mossamedes to Cape Town. On the 4th inst. the India Rubber and Gutta Percha Company's ss. "Silvertown" will sail with cable to connect St. Paul Loando with Mossamedes and Princes Island with Bonny. When the former section and the cables to be laid by the Telegraph Construction Company mentioned above are completed, there will be continuous cable communication from Cape Town to England, in addition to that already existing from Durban to this country. As an instance of the rapidity with which events move in these days it may be mentioned that when this line is completed almost every port of importance on the East or West Coasts of Africa will have been connected by submarine cables within a period of nine years.

Morecambe.—A special meeting of the Morecambe Local Board was held on Tuesday evening last week. Messrs. Andrews and Preece, electricians, Bradford, together with their solicitor, attended before the Board in order to furnish any necessary particulars with reference to their proposed Provisional Order. They stated that in the event of the Board not opposing their application they were willing to fit up a central station and to supply the electric light for ordinary domestic purposes at a charge of 7d. per Board of Trade unit. For public lighting they were prepared to supply twelve 2,000 candle-power arc lamps, 100 yards apart, and at an elevation of 35ft. from the ground, for £25 per lamp per annum; or for 100 nights during the season at £10 per lamp, being 10s. each lamp per night. Six lamps for the same period would cost £11 each. In winter they could substitute incandescent lamps for street lighting at the same price as for domestic purposes, the expense of a 32-candle lamp of that description being estimated at from 28s. to 30s. per year. The Board thanked the firm for the information they had furnished, and promised to carefully consider the question.

Stanford's Map of the London Electric Lighting Areas.—Mr. E. Stanford has issued a new "Map of Metropolitan Railways, Tramways, and Miscellaneous Improvements, as deposited at the Private Bill Office, Nov. 30, for the Session 1889." In this map the "electric lighting areas" are very distinctly shown by means of different colours, and the companies applying for orders are indicated in each case by boldly printed figures, whose meaning is supplied by an index. This map will be indispensable to all who have to follow closely the progress of electric lighting in the metropolitan area. It must, however, be observed that the information which it affords relates only to the Bills now before Parliament, so that, for instance, the existence of the Chelsea Electricity Supply Company, whose Order was confirmed last year, and which promotes no Bill in the present Session, is not in any way alluded to. It is also noticeable that there is still a very extensive district in the south, and another south-west, which have not yet attracted the attention of any supply company. Even the Crystal Palace is left out in the cold. The principal defect of the map seems to be the absence of any indication of the particular local authority which has jurisdiction over the several areas.

Paris Exhibition.—The contract for the lighting of the American part of the Paris Exhibition has been awarded to the Heisler Electric Light Company, of St. Louis. The whole plant for this contract will be completed and tested before shipping at the St. Louis Illuminating Company's station, and the technical societies of the city will be invited to witness the test. The plant consists of a dynamo of 1,000 incandescent light capacity, showing the utility of an independent circuit system, each room or locality wired from both circuits. Lamps will be exhibited from 10 up to 300 candle-power. The automatic regulation will be so arranged as to indicate the reduction of power when the lights are turned off. Ten miles of circuit wire will be inserted, so as to indicate the practicability of carrying the current to any desired distance. Registering current meters will be included in the exhibit; twenty-four clusters of incandescents of various candle-power will be suspended from the ceiling, posts being provided with side brackets, such as are used for indoor, but in addition fifty street-lamp brackets will be fastened to posts, to indicate the system of street lighting used in a great number of American cities.

Testing Chain Cables by Electric Light.—An interesting experiment with the electric light has been successfully carried out recently by the River Wear Commissioners. Hitherto the testing and examining of chain cables had always been done in daylight, no artificial light being considered sufficient to detect the fractures in the cables after testing. That being the case, the management of the River Wear Commission directed that an artificial light of some kind should be experimented upon,

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with the result that the electric light, applied by means of portable lamps attached to the caps of the examiners, has been adopted, and enables the Commissioners to almost double their output in connection with their testing department. Seven 300 candle-power "Sunbeam" lamps, run off one of Parson's turbo-electric generators, were originally installed; but the result of the fixed lights was not altogether satisfactory. Under these circumstances the localising of the light was considered the next best thing to do, and in order to accomplish this a 16 candle-power lamp was attached to the caps of the workmen known as the examiners, with a flexible cable connected with the main cable above, which allows the men to work within a certain radius. This device, which has proved a great success, was introduced by Mr. Hartness, the manager of the Test Works.

Norwich.—At a meeting of the Norwich Town Council on Tuesday last, a report was received from the Electric Lighting Committee to the effect that they did not consider themselves warranted in recommending that the Corporation should undertake the lighting of the city by electricity, but they should forward any scheme for the purpose. Mr. Squirrell said he was the father of the report, and added that there were two courses to be laid down—one was that the Council should take up the electric lighting of the city, and the other was that they should support any sound company that would do the work. As a matter of fact, it would be the best economy for the city to undertake it, the cost being about £15,000 or £20,000, but in the face of the large expenditure for sewerage, &c., that was about to fall upon the rates, he could not recommend the adoption of this course. There was a large demand for the new light, and he had in his hand a list of 60 persons who had applied for the light to be introduced into their shops. This was a fact that ought not to be lost sight of. Mr. Marshall had suggested that when the new sewerage were constructed troughs should be placed for the accommodation of those who required wires, and the Council ought not to obstruct the development of this new industry. It was resolved to consider the question at the next meeting of the Council.

Wakefield.—At the last meeting of the Wakefield City Council Alderman Peacock moved, "That a committee be appointed to consider the question of adopting the electric light for lighting the city, instead of the renewal of the gas contract." He said the contract with the gas company would shortly expire, and he found that the Corporation paid more than £1,908 per annum to the gas company for the public lighting of the city, including the public buildings; and he had an estimate, showing that the lighting by electricity could be done for £995. The estimate had been furnished by an eminent electrical engineer. Alderman Reynolds said he had some five years' experience in electric lighting in establishments of his own firm, and he thought there could not be two opinions with regard to the desirability of having the light where it could be obtained. It would be wrong, however, on his part to allow Alderman Peacock's statement to go forth without some qualification of it. The Mayor said he approved of this question having been brought before the Council for consideration; and he had no doubt that the matter would not be lost sight of by the Sanitary Committee. One thing, however, was certain, that it could not be disposed of prior to the time when the contract with the Gas Company would have to be renewed. Permission to withdraw the motion was then granted.

The Southwark and Deptford Tramways Company.—At the half-yearly meeting of the shareholders of this company on Monday last, the chairman, referring to a Bill now before Parliament, authorising the company to construct new tramways and for other purposes, said:—"With regard to mechanical traction, local authorities were a little sceptical as to mechanical haulage, and therefore the directors had not thought it advisable to jeopardise the safety of the whole Bill by insertion of any clauses in reference to which there could be an objection. They, however, asked for powers to acquire from the Board of Trade a License authorising the use of mechanical power, other than steam, for a period not exceeding twelve months, as an experiment. He was bound to state that he looked most hopefully to the development of electric power. He was not one of those who regarded steam as the be all and the end of all traction. He repeated he had the greatest possible hope in the future of electricity. In regard to its adoption he thought a traction company sufficiently strong financially should say to the tramway company, 'We are prepared to undertake to work your tramway at so much per mile, to include all cost of depreciation and repairs.' If this were done two things were certain; the success of the tramways—an object which he had very much at heart—and the success of the traction company. He firmly believed that electricity was designed to develop and increase the traffic upon the tramways to an extent which it was impossible should be done by any other means."

Barnet.—At a meeting of the Barnet Local Board last week the report of Mr. Preece and his assistant (Mr. Probert) was considered. Mr. Preece reported that the lamps were not all of the candle-power specified, and that although the machinery now employed was capable of supplying 71 lamps with 32 candle-power light, yet it was a great risk to continue the lighting with the existing apparatus. The whole of the apparatus should, in fact, be duplicated. Allowing 20 per cent. for absorption by the thick glass globe enclosing the electric lamp, the average candle-power of the so-called 32 candle-power lamps is, according to the photometric measurements of Mr. Probert, only 27·6, the light varying from 17·34 to 43·65 candles. After a long discussion Mr. Walker moved "That the contractor be called upon to provide uniform lights of 32 candle-power." This resolution, with the words "within fourteen days" inserted, was subsequently carried by five votes to four.—Messrs. Henry F. Joel and Co., electrical engineers, write us as follows:—"In pioneering the system of incandescent lamps in series for street lighting at High Barnet we have had to contend with great opposition and unusual difficulties; but even taking into account the stoppage of the light, owing to uncontrollable causes, such as wilful damage to our wires, &c., the whole of the failures during the past six months and severe winter weather have barely exceeded one per cent. of the total hours of lighting; and this, we submit, is very encouraging, and is, we believe, the best record of town lighting. In the opinion of many qualified engineers who have visited Barnet, the system of street lighting by 32 candle-power incandescent lamps is a success."

City Tradesmen and the Electric Subway Railway.—The members of the City of London Tradesmen's Club are among those who look with disfavour upon the proposed construction of the Central London Subway Railway. At a meeting of the club last week Mr. J. W. Thomas supported the scheme in a comprehensive Paper, which was met, except with the doubtful utterances of a single member, by a unanimous expression of disapproval. Let anyone consider, said Mr. Thomas, the necessities of London in the matter of travelling conveniences. While the population had increased 45 per cent., the traffic had increased no less than 760 per cent. in the United Kingdom, and it was a well-known fact that between 1878 and 1888 the increase of traffic amounted to 360 per cent. Everyone knew that trade begat trade, and that the facilities for travelling created travellers, and the point they should consider was that of the public convenience. Another advantage of the scheme was that the outlay of £100,000 upon the railway meant an increase in the ratable value of the district, and consequently it would be of general benefit to the ward. The railway would be completed within twelve months of its commencement, the thoroughfares would not be obstructed, and the work being carried out in sections only one portion of the street would be disturbed at a time.—Mr. T. Simpson opposed the scheme. He said a great number of houses along the line of route of railway from London Bridge to Stockwell were now "propped up." The proposed new railway would result in a similar propping up.—Mr. N. Phillips considered that it was one of the maddest schemes ever proposed in the City of London.—Mr. B. Turner stated that the electrically-propelled cars might stop short in the tubes, as was sometimes the habit of electrically-propelled cars above ground, and in that case the passengers would have to be dug up.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 393.)

Maxwell's Theory of Molecular Vortices.—The study of the phenomena of electro-magnetic induction naturally gives rise to the question, by what mechanism can this be brought about? Given a medium possessing certain mechanical qualities, such as elasticity, a definite density, and capability of relative displacement of its parts, is it possible to imagine a construction which will mechanically account for the effects we have produced in electrical phenomena? Maxwell has replied to this inquiry by presenting his theory of *Molecular Vortices* which was put forward in the *Philosophical Magazine* for 1861 and 1862. A general account of these conceptions of Maxwell has been given in the "Life of James Clerk Maxwell," and as the limits of such an elementary treatise as the present one preclude any detailed account of the mathematical portion of this theory, we shall borrow the language of the authors of the above-mentioned work* in describing it. Maxwell supposes that any medium which can serve as the vehicle of magnetic force consists of a vast number of very small bodies called *cells*, capable of rotation, which we may consider to be spherical, or nearly so, when in their normal position. When magnetic force is transmitted by the medium or acts through it these *cells* are supposed to be set in rotation with a velocity proportional to the intensity of the magnetic force, and the direction of rotation is related to the direction of the force in the same manner as the *twist* and *thrust* of a right-handed screw. We have thus all the magnetic field filled with *molecular vortices*, as Maxwell calls them, all rotating round the lines of force as axes. These cells as they revolve tend to flatten out like revolving spheres of fluid, and to become oblate spheroids; they thus contract along the lines of force and expand at right angles, creating a *tension* along the lines of force, and a *pressure* at right angles to them. These cells are supposed to be elastic spheres closely packed together and incapable of separating from each other. If any line of cells is set rotating the contraction of each cell along its axis of revolution must set up a tension or pull along that line, it behaves like a filament of muscular tissue, and contracts in length and swells out or increases in thickness. If several adjacent lines of cells or vortices are all set revolving in the same direction, the swelling out of each line causes them to press on each other; hence there is a lateral pressure and a longitudinal tension. In any space filled with these cells so revolving the lines of tension or axes of revolution of the cells will take up certain positions, depending on the necessity for the stresses to adjust themselves to equilibrium, and Maxwell has shown mathematically that such a system of lines of tension and correlated pressure is a force system which will distribute itself in a manner similar to that in which we find actual lines of magnetic force to do, and that the behaviour of magnetic poles to each other can be explained fully on the assumption of a tendency of lines of force to contract like elastic threads along their length, and to push one another apart when laid parallel and proceeding in the same direction. To account for the transmission of rotation from one cell to another in *the same direction*, and from one line of cells or vortex to the next, Maxwell supposed that there exists between the cells a number of extremely minute spherical bodies which can roll without sliding in contact with the vortex cells. These bodies serve the same purpose as "idle wheels" in machinery which, coming between a driving wheel and a following wheel serve to cause both to turn in the same direction. These minute spheres Maxwell supposed to constitute *electricity*. We shall speak of them collectively as the electric matter. These electric particles are furthermore supposed to be free to move in conductors; but in dielectrics they are tethered to one spot, or rather into one molecule of the substance, and can only be displaced a little way against an elastic resilience, which brings them back to their original position when the displacing force is withdrawn. Furthermore, we must assume that both cells and particles are very small, compared with the molecules of matter. The passage of electric particles from molecule to molecule in conductors, however, sets up molecular vibration, or generates heat. Something of the nature of friction must, therefore, be also postulated to account for the fact that the electric particle, when set moving in a conductor, gives up energy to the molecules, and the energy is in them dissipated in the form of heat. That there is some kind of rotation going on along the lines of magnetic force has been held by Maxwell to be indicated by the behaviour of a ray of polarised light when passing through a dielectric along a line of magnetic force, and he states* that Faraday's discovery of the magnetic rotation of the plane of polarised light furnishes complete dynamical evidence that wherever magnetic force exists there is matter, small portions of which are rotating about axes parallel to the direction of that force. The further assumption is made that the *cells* are composed of an elastic material, and that they can be distorted or squeezed slightly, returning again in virtue of their resistence to their original form. In order to obtain a clear mechanical conception of the inter-relation of the idle wheels or the electric particles and the revolving cells or lines of induction, let us figure to ourselves one element of the mechanism as it is supposed to exist in the dielectric.

Consider A and B (*see* Fig. 26) to be two wheels of india-rubber, and that C is another small wheel lying between A and B and transmitting motion from one to the other. Let C be

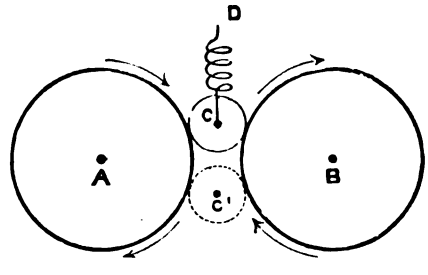

FIG. 26.

tethered to a fixed point, D, by an elastic spring, and let C be at the same time capable of rotation round its centre. Suppose A is set in rotation, clock-hand wise, whilst B is held fast, and that the wheel C cannot slip on A, the result will be to drag down C to the position of C^1, stretching the spring and displacing C. Let B be then set free; the wheel C continues to roll on A, and transmits its rotation to B. Owing to the assumed elasticity of the discs A and B, the wheel C can be drawn down between them, and yet within the limits of its displacement equally transmit the rotation of A to B without slip. This same action of a preliminary displacement of C and subsequent rotation of B will take place if the wheel B possesses *inertia*—that is, if we assume it to be a heavy wheel which cannot in virtue of its mass be set rolling with finite speed in an infinitely short time.

If, then, we suppose a long row of such wheels with intermediate displaceable idle wheels, the main wheels being heavy bodies, the result of causing the first wheel to rotate would be to propagate along the line a successive displacement of the idle wheels, and to set the main wheels successively in rotation. Translating these mechanical concepts into their electrical equivalents Maxwell considers that the heavy wheels are the analogues of the molecular votices or lines of force, and that their density is determined by what we call the magnetic permeability of the medium; the elastically displaceable idle wheels are the electricity in the dielectric; and that when a line of force is brought into existence in a dielectric, or, in other words, when a line of cells is set rotating, this action propagates itself outwards, producing successive displacements of the electric particles, or generates a displacement wave, and is

* "Life of James Clerk Maxwell." By Lewis Campbell and William Garnett. 1st Edition. 1882.

The general description of Maxwell's views in the above-mentioned work is due to Prof. Garnett, and in the annexed paragraphs the expository account of this theory is taken in part almost verbatim from the pages of this book.

* Article "Faraday," *Encyclopædia Britannica*, 9th edition.

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accompanied by the successive appearance of rotation in the cells, or by the propagation of a wave of electromagnetic force.

The velocity of propagation of this wave will depend on the elastic forces restraining displacement, and on the inertia of the revolving vortices. We have seen that the elasticity of the dielectric is expressed by the quantity $\frac{4\pi}{K}$, where K is the specific inductive capacity. We shall see later on that the electromagnetic density of the medium is expressed by $4\pi\mu$, where μ is the magnetic permeability.

The velocity of propagation of a disturbance through an elastic medium is numerically equal to the quotient of the square root of its effective elasticity e, by the square root of its density d, or by $v = \frac{\sqrt{e}}{d}$.

If, then, for the electromagnetic medium $e = \frac{4\pi}{K}$ and $d = 4\pi\mu$ we have $v = \frac{1}{\sqrt{K\mu}}$, or the velocity of lateral propagation of a wave of electric displacement or of magnetic force in a medium is numerically equal to the square root of the reciprocal of the product of its specific inductive capacity and its magnetic permeability. Such a mechanical hypothesis shows us how the spin of one line of vortices results in producing displacement of the idle wheels or electricity along lines which are circles described round the initial vortex as axis, and in propagating outwards the vortex spin or magnetic force with a finite velocity from one line of molecular vortices to another.

(To be continued.)

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION III.—MAGNETIC FIELDS OF COILS AND SOLENOIDS.

(Continued from page 435.)

[In the curve showing the strength of field at various distances from a coil along its axis (Fig. 135) more points on the curve should have been taken. It then appears that when the distance from the coil is very small the rate of decrease of field is more gradual and the curve is of the shape shown in Fig. 135A. For some little distance each side of the coil the fall

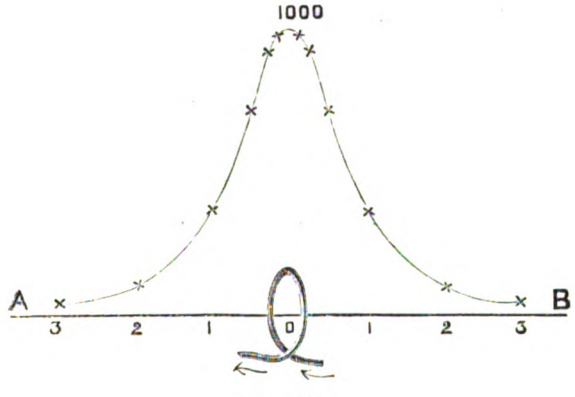

FIG. 135A.

in strength of field is very gradual; then it suddenly becomes rapid, and then gradual again. Its most rapid fall is at a distance equal to half the radius of the coil. Also in the numerical example given at the end, the field at the coil centre should be

$$\frac{113}{4} = 28{\cdot}25 \text{ C.-G.-S. units.}]$$

146. *Magnetic Fields due to a Coil and Magnet Superposed.*—We have already discussed the case of two uniform magnetic fields superposed at right angles to each other (para. 119). Referring again to the figure (Fig. 80), it was shown that the ratio between the two superposed fields f and H was the tangent of the angle which H, the total controlling field, makes with the resultant. Let us now take the practical case which occurs in every tangent galvanometer, viz., the superposition at right angles to each other of the controlling field due to the earth or a permanent magnet, and the field due to the current in the coil. A little experiment carried out with a Thomson potential galvanometer coil and a battery of secondary cells may serve to make this action clear. This instrument is of the same external appearance as the current galvanometer described in para. 132, but instead of a few turns of stout copper strip the coil is wound with some 8,000 turns of German silver wire, amounting to a resistance of 9,830 ohms. The needle-box, movable along the wooden platform, being removed, the magnetic fields produced in the region of the coil were examined by iron filings sprinkled on a sheet of stiff card placed on the platform. First, without any current through the coil, the controlling magnet N S was placed over it in the usual position as used with the instrument (Fig. 136). The iron filings then revealed the kind of field produced in the region of the coil. The lines of force here pass straight from one pole of the magnet to the other, producing at the centre of the coil a field parallel to its plane. When in use the coil and magnet are put in the

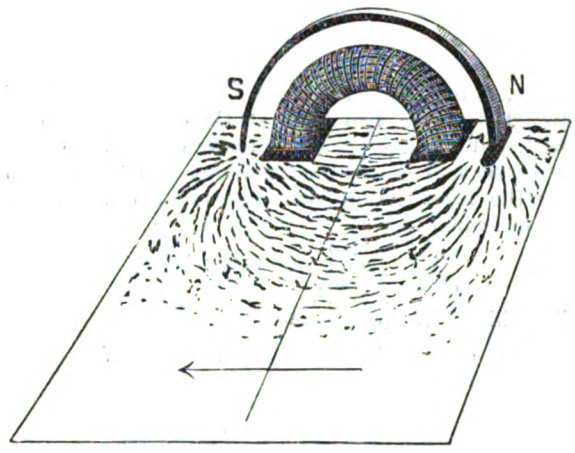

FIG. 136.

plane of the magnetic meridian so that the earth's horizontal field is added to that of the magnet. This field alone is far too weak to be exhibited by iron filings. The central line in the figure represents the axis of the coil, and is the line along which readings are taken with the instrument. Along this axis we may consider the controlling field produced by the magnet and the earth to be everywhere in the direction of the arrow—viz.: at right angles to the axis. For even at positions along the axis remote from the coil where the lines are in curves, the direction of each line of force *as it crosses the axis* is a tangent to the curve, and, therefore, at right angles to the axis. Secondly, the controlling magnet was removed, and the ends of the coil connected by leading wires to the terminals of 21 cells, giving a difference of potential of 42 volts at the terminals of the coil. A vigorous effect was then produced on the filings, which arranged themselves into the form in Fig. 137. It will be noticed that as regards the axis of the coil, this field is at right angles to that set up by the controlling magnet. The current was sent round the coil in such a direction as to cause the direction of the lines to be *towards* the coil, as shown by the arrow. Lastly, the controlling magnet was placed over the coil, as at first, the current being kept on the while, resulting in the change in direction of the filings represented in Fig. 138.

Here we have an actual representation of the resultant field, that is, the character of the field resulting from the combined effect of two distinct fields at right angles to one another. The arrow in this figure indicates the direction of the lines of the resultant field at the centre of the coil. As we take points on the axis further away from the coil the effect of the

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latter becomes rapidly decreased, and the controlling field predominates, so that the lines become nearer and nearer at right angles to the axis. The direction of this resultant field is precisely that taken up by a magnetic needle free to move when placed at a given position on the axis of the coil. If the needle is at the centre of the coil we have an ordinary tangent galvanometer, and if the box containing the needle can be shifted along the axis of the coil, as in Sir William Thomson's graded galvanometers, we have instruments which still follow the tangent law, and which have, in addition, the advantage of great variation in

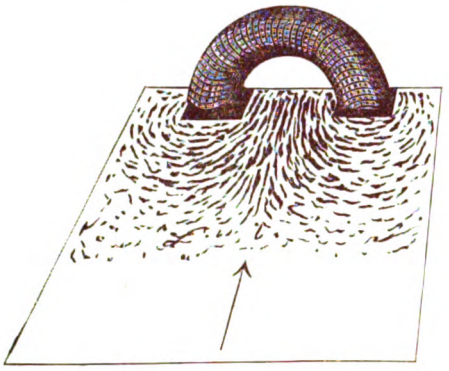

Fig. 137

sensibility, as before explained. Let us form a practical idea of the strengths of the two fields at the centre of the coil, their resultant, and its direction in the above case. The outside diameter of the coil was 14 centimetres, and the inside 6 centi metres; the mean radius was therefore 5 centimetres. The current was equal to

$$\frac{\text{volts}}{\text{ohms}} = \frac{42}{9830} = \cdot00427 \text{ amperes.}$$

Dividing this by 10 we have the

current in C.-G.-S. units = ·000427.

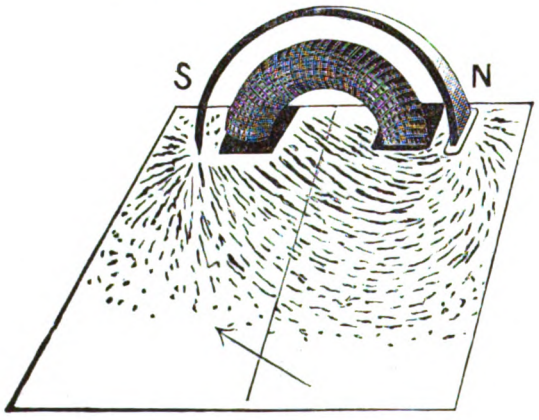

Fig. 138.

The number of turns of wire being 8,000, the field at the centre of the coil due to the current was :—

$$\frac{2\pi \times \cdot000427 \times 8000}{5} = 4\cdot3 \text{ C.-G.-S units.}$$

Now, the controlling field at right angles to the above consisted of the field of the magnet, which was 10·56 C.-G.-S. units, plus the earth's horizontal field ·18 unit, total 10·74 units. The ratio of the coil field to the controlling field is the tangent of the angle which the resultant makes with the controlling field, that is

$$\frac{4\cdot3}{10\cdot74} = \cdot4003 = \text{tangent of } 22^\circ \text{ nearly.}$$

A small magnetic needle freely suspended at the centre of the coil would therefore turn through this angle when the above potential difference was applied at the terminals of the coil.

(To be continued.)

THE TESLA MOTOR.

Although the theory of the Tesla motor is now so widely known—though doubtless better known than understood—yet the practical construction of the apparatus has not yet been explained. The following brief description will therefore be read with interest :—The field-magnet consists of a laminated ring, with internal projections like Paccinotti teeth. It is wound with two independent circuits, A and B ; in the motor from which the diagram is taken there are 12 scctions in all, and the two coils are wound upon every three sections alternately. The three sections on the right of the figure, and the three on the left, the two being joined in series form circuit A. Similarly, the three upper and the three lower sections form circuit B. The resultant fields of each coil independently are shown by the lines $N_A S_A$, $N_B S_B$, respectively. But the currents in these two circuits are relatively displaced by $\frac{1}{4}$ phase. Thus, when the current in A is at a maximum, the current in B is at zero, and the resultant field for both coils passes through $N_A S_A$; so, also, when B is at a maximum and A is at zero, the resultant is $N_B S_B$. But when the two currents are equal the resultant passes through the line N S ; the direction of the resultant is, of course, reversed at the moment when the two currents are equal in value but opposite in direction.

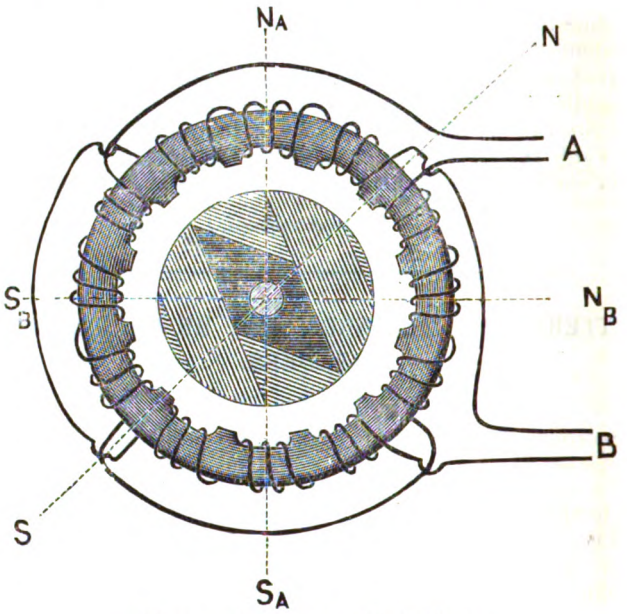

Diagram of Windings of Tesla Motor.

The armature is drum-wound, with four coils, as shown, each being short-circuited on itself. The resultant axis passes through N S.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

"On Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits."

BY A. E. KENNELLY.

(Concluded from page 456.)

One of the most interesting features in the geology of Nova Scotia is that the Atlantic seaboard presents an uninterrupted line of Lower Cambrian formation. The relation of this fact to our immediate subject is patent when we remember that these rocks—early in order of geological structure, and said to be almost destitute of organic remains—are here almost entirely composed of argillites, quartzites and micaceous schists—slates and grits—substances experimentally known to be non-conductors ; and according to the published Papers of Prof. Honeyman, who has studied the geology of Nova Scotia for many years, no other formations mingle with the Lower Cambrian in the structure of the Halifax basin except the still lower archæan granites, all of which are presumably non-conductors. In fact, the renowned natural advantages of Halifax Harbour are due to the unrelieved presence of these abrupt slaty cliffs that immediately underlie the soil for miles inland.

The question then arises, Granting that on the above geological considerations the rocky basin of the harbour and foundation of the city form an insulating crust, or one, at least, interposing a decided amount of resistance between the superficial conducting system and the ocean or earth's mass—is the resistance that can be jointly

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offered by the three cable sheathings and the whole waterway between the cable house and open sea of sufficient magnitude to produce the degree of interference observed ?

The answer, which seems to be affirmative, strictly demands a computation of the resistance offered by the entire mass of sea water in the harbour under those conditions. This would be a gigantic problem to solve with any pretence to accordance with nature ; but for the purposes of the case such limitations may be admitted as shall greatly simplify the calculation.

The map shows that three channels open upon the inner harbour, one running inland through the narrows, and two passing seawards —the eastern passage, and the main or southern entrance. The inland channel terminates in a bay some miles beyond, and may be considered to be practically insulated with the rest of the basin. The waterway in the shallow and narrow eastern passage will evidently offer a comparatively high resistance compared with that of the main entrance, which, therefore, demands principal attention.

The general mathematical theory of the earth's resistance is given in Schwendler's "Testing Instructions," following the reasoning of Smaasen's theory, published in 1847. It is shown that if a perfectly conducting small spherical electrode of radius r were situated concentrically within a larger hollow perfectly conducting sphere of radius R, and the intervening space filled with a homogeneous substance of specific resistance ρ, the resistance of any elementary spherical shell of radius x, measured from the common centre, would be $\frac{\rho\, dx}{4\pi x^2}$, and hence the total resistance (ω) between the two spherical electrodes would be the integral of this quantity between the limits $x = \mathrm{R}$ and $x = r$; whence

$$\omega = \frac{\rho}{4\pi}\left(\frac{1}{r} - \frac{1}{\mathrm{R}}\right).$$

If the radius R of the outer electrode be indefinitely increased, the resulting equation becomes

$$\omega = \frac{\rho}{4\pi r},$$

which represents the resistance of an unlimited medium of resistance ρ to a current passing from a sphere of radius r to its ultimate confines. Similarly, a second small spherical electrode of radius r_1 would offer under the same circumstances a resistance

$$\omega_1 = \frac{\rho}{4\pi r_1};$$

and if these two small spherical electrodes were placed so far apart in the medium that their direct influence on each other's lines of current-flow would be very small, the resistance between them would be

$$\omega + \omega_1 = \frac{\rho}{4\pi}\left(\frac{1}{r} + \frac{1}{r_1}\right)$$

—a result equivalent to the statement that almost all the lines of current-flow issuing from the surface of each electrode would unite with least opposition at indefinitely great distances, and after indefinite diffusion throughout the medium.

If the system were then symmetrically divided by an unlimited insulating plane, the resistance (Ω) between the hemispheres on one side of the plane would be double the above, or

$$\Omega = \rho\left(\frac{1}{c} + \frac{1}{c_1}\right),$$

where c and c_1 are the circumferences of the two hemispheres.

This would then be the resistance between two hemispherical electrodes embedded in the bounding plane surface of an indefinitely extending homogeneous medium ; and if the electrodes were not hemispheres, but vertical plates embedding active surfaces (s and s_1), the above formula would approximately apply, if c and c_1 be the circumferences of equivalent hemispheres exposing those areas respectively, and the transformed equation would be

$$\Omega = \frac{\rho}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{s}} + \frac{1}{\sqrt{s_1}}\right)$$

—an equation independent of the distance between the plates.

Similar results are obtained and published by MM. Mascart and Joubert by separate reasoning. The formula applies to the earth's resistance in a telegraphic circuit, on the assumption that our planet has a practical uniform conductivity, and forms practically an indefinitely extended medium.

In the absence of experimental evidence it would be difficult to say how far the variable conductivity of the earth's mass would affect the application of this formula. The conductivity of the material composing the earth's crust probably varies considerably in different localities, and is generally not the same as that of the ocean, for example. It might even be assumed that the resistance of the primary rocks is so great as to limit the conducting area almost entirely to the superincumbent stratified formations.

In that case the earth's telegraphic resistance would be mort nearly comparable to the resistance between two small distince electrodes embedded in the surface of an indefinitely extended sheet of uniform thickness and conductivity. On this supposition, let d be the depth of the earth's conducting crust, assumed to be uniform, then the resistance, Ω (*vide* Appendix), between two earth-plates of active surfaces (s and s_1) would be, approximately,

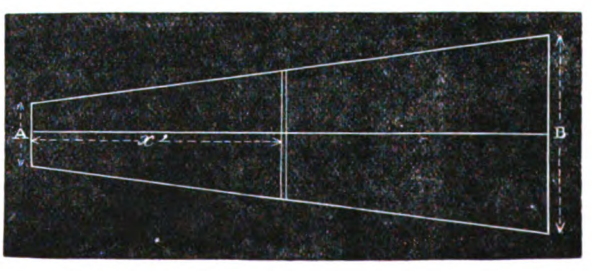
$$\Omega = \frac{\rho}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{s}} + \frac{1}{\sqrt{s_1}}\right) + \frac{\rho}{\pi d}\log_{\varepsilon}\left(\frac{4\,\mathrm{D}}{d}\right).$$

This equation is the same as that of Schwendler last stated, but with the addition of a second term involving D, the distance between the plates ; so that on this theory the earth's resistance would increase with the length of the circuit. If submarine cables were sufficiently well insulated, it would be possible to ascertain which of these two theories is nearer to the truth, by measuring the conductor resistances of cables which are laid in duplicate or triplicate between two stations ; the difference between the resistance of any pair looped, and the sum of their separate resistances employing the earth circuit, giving, of course, double the earth's resistance between the terminals. It is, however, impossible to decide from present experimental evidence in this way, since not only does the difficulty of accurately measuring these quantities probably increase with the square of the length of cable, owing to leakage and other causes, but also because this second term of the last equation whose existence is in question must in all cases be very small.

Generally speaking, therefore, the experimental evidence may be said to establish the results given by Schwendler's formula, namely, that when the earth-plates are separated by any distance great compared with their dimensions, the resistance varies with their active area, and is independent of their distance.

Schwendler gives an estimated superior limit of the specific resistance of the earth in India as 3,300 ω, or about 100 times that of saturated zinc-sulphate solution at 10°C.

Returning to the resistance offered by the waterway in the main entrance of Halifax Harbour, we may suppose a current to be flowing seawards through it and the cable sheathings from the cable house. The lines of flow will permeate its whole area, and the equipotential surfaces may be supposed to form across it in successive curves. These surfaces will be practically vertical, and a position has to be assumed for the ultimate one representing the zero-potential, or the surface that may be considered to mark the limit of perfect earth connection. Theoretically, of course, this limit would be far out in the ocean, but it may be arbitrarily assumed that a vertical plane shown on the map by a dotted line connecting the Thrumcap with the Mars Rock buoy represents this boundary, and that the resistance to earth of the ocean mass outside this plane is altogether negligible. The two other dotted lines converging from this base up to the cable house—one skirting Sandwich Point, and the other running over Maugher Beach—are intended to represent what may be considered the simple boundaries of an equivalent waterway equal in conductivity to the actual one. The average depth may be taken as 14 fathoms. We have, on this supposition, a mass of sea-water resembling a wedge with a blunt point, the breadth of the base being 1·2 knot ; the breadth at the apex, say, 5 metres ; the length, measured perpendicularly to the base, 4 knots ; and the depth 14 fathoms. Strictly speaking, the equipotential surfaces of flow



will be curves convex to the ocean, but the error introduced will not be great if we consider them as planes parallel to the base, or zero surface. Since the fall of potential will take place with equal rapidity through the water and through the sheathings, the resistance of the latter may be taken into account later and independently. The resistance of any elementary lamina of thickness dx, distant x from the cable house, will be $\frac{\rho\, dx}{h(ax+b)}$, where ρ is the specific resistance of the water, h the depth, while a and b are constants ; so that the total resistance between the two ends is

$$\mathrm{R} = \frac{\rho}{a\,h}\log_{\varepsilon}\frac{\mathrm{B}}{\mathrm{A}},$$

where B and A are the breadths at the base and apex.

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In this case $a = \frac{1{\cdot}2}{4{\cdot}0} = 0{\cdot}3$;

$h = 14 \times 6 \times 30{\cdot}5 = 2{,}560$;

$\frac{B}{A} = \frac{185{,}000 \times 4{\cdot}2}{500} = 1{,}550$;

$\rho = 31$.

The specific resistance of a saline solution of density 1·027 has been observed experimentally to be about 31 ω at 5° C.

With these data,

$$R = \frac{31 \times 2{\cdot}72 \times 3{\cdot}19}{0{\cdot}3 \times 2{,}560}$$

$$= 0{\cdot}35\ \omega,$$

about one-third of an ohm, equivalent to a conductivity of ..... 2·9 mhos.

Compared with this, the conductivity of the eastern passage channel may be estimated at about one-fourth, or ..... 0·7 mho.

The conductivity of the two cable sheathings, each consisting of ten No. 6 wires, and length 4·2 knots, would be $20 \times 0{\cdot}020$ ..... = 0·4 mho.

And, finally, the conductivity of seven knots of cable sheathing in the eastern passage, $10 \times 0{\cdot}012$ ..... = 0·1 mho.

Total conductivity ..... 4·1 mhos.

equivalent to a joint resistance of 0·24 ω. So that if the above reckoning is sufficiently fair the resistance between the cable-house and the ocean is about a quarter of an ohm.

The resistance actually offered can be estimated from the data of Experiment 11, as follows :—

The E.M.F. in the exciting circuit was about 15 volts ; the resistance, 66 ω in the cable and earths, and 24 in the battery—total, 90 ω. In the Rye Beach circuit the resistances at the time were, approximately—

Observing mirror	2,000 ω
Cable conductor	5,800
Relay at Rye Beach	1,000
Total	8,800 ω

Since the interference current observed in this circuit was, as already mentioned, 5×10^{-6} amperes, the E.M F. impressed upon the cable due to interference was

$$5 \times 10^{-6} \times 8{\cdot}8 \times 10^{3} = 0{\cdot}044 \text{ volt};$$

and, consequently, if x be the required resistance of the general earth connection,

$$x : 90 :: 0{\cdot}044 : 15,$$

or

$$x = 0{\cdot}26\ \omega,$$

or an actual resistance of a quarter of an ohm. The agreement between the actual and measured values is really much closer than the accuracy of either determination would warrant.

The only experimental results still left unaccounted for are those of Nos. 3, 4, 5, and 6, in all of which the six-mile earth was used either in the exciting or observing circuit, and since Experiment 13 proved that this earth-plate was outside the limits of the semi-insulated basin, as might be expected from its position on the map, it would be impossible to account for the interference in those cases on the score of a common imperfect earth. Reflection shows, however, that the interference observed would be an indirect necessary consequence of the imperfect earth, since the six-mile earth, when connected to either main circuit, forms a cable-loop of, say, 10 knots within the limits of the semi-insulated basin, and a slight variation in the potential of the basin is calculated to produce a considerable electrostatic effect on the cable. It has, in fact, been found experimentally that when 1,000ft. of insulated cable core (of similar capacity to that of the cables at Halifax) are coiled in an insulated tank and left in communication with the earth through a mirror instrument, the electrostatic disturbance of the mirror is about equal to that observed in these experiments (3-6) when the potential of the tank is altered by 0·2 volt. The total charge passing through the mirror in Experiments 3 and 6 would be the resultant effect of the whole system of harbour potential variation on the four knots of cable under observation, except in so far as the capacity of the cable seawards would modify the influence. In Experiments 4 and 5 the interference would, on the other hand, be due to electrostatic charge entering the observing circuit owing to the variation in the harbour potential, electrostatically produced by the loop of exciting cable traversing it. An external average variation of 0·01 volt in the potential of the basin would suffice to account for the degree of interference observed ; and this amount of variation, it is evident, the conditions amply supply. Experiment 13, contrasted with Nos. 9 and 11, showed that the interference observed in cases 3, 4, 5 and 6 was of an electrostatic nature.

The sensitiveness of a cable to external electrostatic influence can be shown experimentally by joining up a mirror galvanometer in circuit with 100 miles of cable and earth. If the distant end be sealed, and laid for two or three feet in an insulated joint trough filled with water, the potential of which is capable of being varied suddenly through 100 volts (from + 50 to − 50), the effect is immediately visible on the galvanometer ; and in fact, simple signals have been transmitted in this way from ship to shore through the coatings of a joint.

The hypothesis of an insulated or semi-insulated basin, therefore, satisfactorily explains all the phenomena observed. It accounts, first, for the meteorological disturbances which are observed on the cables, since any alteration of the charge or position of electrified clouds in the vicinity of the harbour may affect the distribution of charge in the cable to an extent that would not be possible if the harbour were in more perfect electrical communication with the ocean or earth's mass ; and all the phenomena experimentally observed can be traced either to the direct or indirect effects of this imperfect earth connection—directly by conduction, indirectly by induction.

Assuming, then, that the Lower Cambrian rocks effectively insulate the Halifax basin, it is necessary to suppose that the same effect would be produced at any landing place on the Atlantic shore of Nova Scotia, where these rocks so generally prevail. This is also corroborated by the fact that previously at Torbay some difficulty of the same kind appeared when attempts were originally made to utilise an ordinary earth connection for an overhead Morse circuit. The interference with the cables thus set up rendered a special earth necessary for the land line in the bay. The fact that no interference was visible between the cables themselves is accounted for by the open landing place and absence of any such basin as Halifax Harbour presents.

In Mr. James Graves's Paper on earth vibrations, already alluded to, mention is made of the slaty character of the rock in the neighbourhood of the station, and so favours the supposition that the interference there observed was due to the same causes.

It is said that in the Lake Superior region of the United States great difficulty has occasionally been found in obtaining efficient earth, even when no local cause for the deficiency has been apparent. I am indebted to Prof. Moses G. Farmer for the facts of a case which came under his own notice, where an earth connection, apparently good and well situated, was found useless, and measurement showed that its resistance to earth was 12,000 ω. I also owe to him the information that interference due to imperfect earth was found in 1869 at St. Pierre Miquelon, the Morse signals on the St. Pierre Placentia circuit affecting the Atlantic cable to Brest, and that special measures had to be taken to effect a better earth connection.

Generalising from these facts, it would seem that there may be difficulty in obtaining good earth at cable stations opened on a shore of primary or metamorphic rock, and that permanent interference beyond remedy by earth connection is possible between cables landed in a basin of such formation ; so that if this statement receive confirmation at the hands of the members of this institution, it will be evident that a due regard will be given to geological conditions by electrical engineers among the many incidental considerations that determine their selection of a cable's landing place.

APPENDIX.

On the resistance between two electrodes of active surface (s and s_1) embedded in the surface of an indefinitely extended homogeneous medium of specific resistance ρ comprised between two unlimited parallel planes separated by a perpendicular distance, d, the distance between the electrodes being represented by D.

Let r and r_1 be the radii of the equivalent hemispheres exposing surfaces of s and s_1 respectively. Then, if an infinitely thin perfectly conducting hemispherical shell of radius d concentrically surrounds each of these electrodes, these shells will touch the opposite bounding plane of the medium, and the resistance between them and their included electrodes will be

$$\frac{\rho}{2\pi}\left(\frac{1}{r} - \frac{1}{d}\right) \text{ and } \frac{\rho}{2\pi}\left(\frac{1}{r_1} - \frac{1}{d}\right) \text{ respectively.}$$

If D be large compared with d, these two shells may be approximately considered as two paralled cylinders of radius $\frac{d}{2}$ traversing the medium at right angles to the bounding planes, and their surface potentials may be written*—

$$V_1 = \text{constant} - \frac{c\rho}{2\pi d} \log_\epsilon \left(\frac{\frac{d}{2}}{D}\right);$$

$$V_2 = \text{constant} - \frac{c\rho}{2\pi d} \log_\epsilon \left(\frac{D}{\frac{d}{2}}\right),$$

* See Mascart and Joubert's "Electricity and Magnetism," Vol. 1., p. 235.

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where V_1 and V_2 are the potentials and c the strength of current.

$$\therefore V_1 - V_2 = \frac{c}{2\pi d}\left(\log\frac{2D}{d} - \frac{\log d}{2D}\right),$$

$$\therefore \text{Resistance} = \frac{\rho}{\pi d}\log_\epsilon\left(\frac{4D}{d}\right);$$

so that the total resistance,

$$\Omega = \frac{\rho}{2\pi}\left(\frac{1}{r} + \frac{1}{r_1} - \frac{2}{d}\right) + \frac{\rho}{\pi d}\log_\epsilon\left(\frac{4D}{d}\right);$$

and since d is large,

$$\Omega = \frac{\rho}{\sqrt{2}\pi}\left(\frac{1}{\sqrt{s}} + \frac{1}{\sqrt{s_1}}\right) + \frac{\rho}{\pi d}\log_\epsilon\left(\frac{4D}{d}\right),$$

approximately.

PATENT RIGHTS IN SECONDARY BATTERIES.

The *Electrical World* (New York) publishes the following interesting statement from President D. H. Bates, of the Electrical Accumulator Company :—"The manufacture of secondary batteries in the United States is increasing rapidly with the growing demand for this form of apparatus in electric lighting and applications of power. The question as to whether or not the broad features of improvement attributed and patented to Faure are to be secured to his assignees, the Electrical Accumulator Company, is now in the hands of Judge Cox, and a decision will be rendered very shortly. The recent decision in the United States Supreme Court in the Bate refrigerating case has eliminated the only defence having any apparent merit. Faure's invention, as is well understood, was the application of an active material to a plate or support prior to immersion in the battery fluid. Subsequent inventors modified the nature and form of the support plate and the manner of combining this support plate and the active material. Among batteries now obtainable, whether at the hands of authorised manufacturers or infringers, are those having a support plate of lead, others having a support plate of lead and antimony with perhaps a little mercury added ; and, as regards the form of plate, the key-lock principle is applied to all. Perforations having a smaller diameter at or near the centre of the plate meet with the greatest success ; others have cells or perforations, the greatest diameter being at points intermediate between the surfaces of the plate. Your patent record shows that the specific modifications mentioned were long since contemplated and patented by an English inventor.

"The result of the recent interference between the application of John S. Sellon, of Hatton-garden, England, and Edmond Julien, assignor to the Julien Electric Company, is shown by the issue to the Electrical Accumulator Company (Sellon's assignees) of patent No. 396,958, dated Jan. 29, 1889, claim 2 being the issue in interference, to wit : 'In a secondary battery a plate, element, or support containing lead and antimony in combination with an active material.' Recent publications emanating from Julien's assignees give an impression widely at variance from what the issue of this patent shows to be the facts. The language of the technical expert of the Patent Office, not referred to in the publication of the Julien Company, shows what the facts really are :—'If Sellon was the first to use plates formed of lead and antimony, or two or more metals, of which lead and antimony are essential, I can see no good reason why he should not claim his invention in such broad terms as would prevent its being pirated by the addition of a small percentage of some other metal. The addition of a small proportion of zinc, tin, or bismuth, all of which are well known constituents of type metals, which are essentially alloys of lead and antimony, would avoid any patent he might obtain unless he is protected by some such claim as the one in interference, and the purpose of the claim seems to be to protect him from just this danger. Julien's claim is included in and subordinated by the claim of Sellon, for the reason that it is directed to an alloy of which lead and antimony are essential ingredients.' The issue of this patent gives Sellon's assignees, the Electrical Accumulator Company, the control of the battery employing an alloy plate, whether the present suit based upon the Faure patent now in the judge's hands, and upon which a decision may be expected within a short time, is favourable or unfavourable.

"A second very important patent granted on the same date to the assignees of Sellon for improvements in secondary batteries, No. 396,770, is also of sufficient importance to merit special attention. This is intended to cover and covers a special form of perforated plate, such as is used by the Gibson Electric Company, and such as is shown in the recent modification of Faure's invention attributed to Anthony Reckenzaun. The Gibson battery makes more or less successful use of a perforated plate produced by piercing a sheet of lead with a series of perforations in such a manner that the openings at the surface of the plate are smaller than the diameter of the perforation at one or more points intermediate the surfaces. The claims of this patent, as will be seen from the example given, cover this construction ; for instance :—'In a secondary battery a plate, element or support having cells, perforations or receptacles, the diameter of which at or near one or both poles of the major axis is less than the diameter at one or more points intermediate said poles.' This gives the assignees of Sellon a practical control of the form of battery manufactured by the Gibson Company, the invention of Sellon, as shown by his English patent, having been perfected long before the construction was adopted by Gibson.

"The third patent covers the construction adopted by FitzGerald-Jones in England when they were manufacturing batteries for experimental or exhibition purposes. The FitzGerald-Jones plan was to mould a solid peroxide plate and attach a framework of celluloid to the edges and parts of the surface thereof. On the inside of this frame, between the frame and the peroxide plate, was a thin strip of platinum ; but this construction was contemplated and perfected by Sellon long prior to the time of its adoption by Fitz-Gerald-Jones. This third patent, No. 396,769, was issued on the same date as the others above referred to. One claim reads : 'In a battery a support or terminal containing a practically inoxidisable material, combined with a conductor of platinum and a mechanically applied active material substantially as described.'

"These three patents are all believed to be valid ; if so, their ownership places the Electrical Accumulator Company in position to control the accumulator or secondary battery industry of the Faure patent."

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, March 1st.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Leigh Hunt." By EDMUND GOSSE, M.A.

SATURDAY, March 2nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation : Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

MONDAY, March 4th.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Westminster Town Hall. "The Construction and Repair of Roads." By G. R. STRACHAN, A.M.I.C.E.

ROYAL INSTITUTION.

5 p.m. General Monthly Meeting.

TUESDAY, March 5th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Paper to be further discussed, "Alternate-Current Machinery." By GISBERT KAPP, A.M.I.C.E. At this meeting the monthly ballot for members will be taken.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture. "A Visit to the Moon ; how we got there and what we saw." By Prof. CARLTON LAMBERT.

WEDNESDAY, March 6th.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

7 p.m. Ordinary Meeting at the Westminster Palace Hotel, "Liquid Fuel." By E. A. BRAYLEY HODGETTS.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Arc Lamps and their Mechanism," By Prof. SILVANUS THOMPSON, D.Sc.

FINSBURY TECHNICAL COLLEGE ENGINEERING SOCIETY.

8 p.m. "Boiler Explosions." By L. PENDRED.

THURSDAY, March 7th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Venom of Serpents and Allied Poisons." By SIDNEY MARTIN, M.D., B.Sc.

FRIDAY, March 8th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Notes on Mining in Spain, with special reference to the Lead Mines of Linares." By C. F. SMITH, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "The Discharge of a Leyden Jar." By Prof. OLIVER LODGE, F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 473
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 478
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 479
The Tesla Motor. Illustrated.. 480
The Institution of Electrical Engineers. — "On Certain Phenomena Connected with Imperfect Earth in Telegraph Circuits." By A. E. Kennelley. Illustrated. Concluded 480
Patent Rights in Secondary Batteries 483
Meetings of Scientific Societies. 483
The Society of Arts' Trials of Motors for Electric Lighting 484
Reviews 486
On the Designing of Continuous-Current Dynamo Machines. By Prof. Jamieson, M.I.C.E., F.R.S.E. Illustrated 487
Physical Society—
"Electrical Measurement."... 489
The Fein Arc Lamp. Illus..... 490
Legal Intelligence—
King, Brown and Co. *v.* The Anglo-American Brush Electric Light Corporation (Limited) 490
American Notes 491
Correspondence—
An Experiment in the Theory of Electrolysis by Prof. W. Ostwald, of Leipzig. Illustrated.—Oliver J. Lodge... 493
Discharge of a Leyden Jar.—Oliver J. Lodge..... 494
Harrow Lighting.—R. E. Crompton 494
Electric Bleaching.—A. Andreoli 494
Electric Lighting Companies at Kensington and West Brompton.—R. S. Erskine. 495
The Kensington Vestry Report.—R. S. Erskine 495
Companies' Meetings, &c.—
Telegraph Construction and Maintenance Company (Limited) 495
Submarine Telegraph Company (Limited)..... ... 496
City Notes, &c..... 497
Companies' Share List..... 498

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THE SOCIETY OF ARTS' TRIALS OF MOTORS FOR ELECTRIC LIGHTING.

In our issue of February 15th we briefly announced that the trials of small motors for electric lighting, instituted by the Society of Arts, had resulted in the award of a gold medal to each of the four competitors. Without wasting time in recapitulating the history of this affair, which has, in fact, been already chronicled in these pages, we proceed briefly to describe the motors entered, and the result of the tests carried out by the judges. It will be remembered that at the request of the Council the duty of conducting the tests, and awarding the medals, was undertaken by Prof. A. C. W. Kennedy, F.R.S., Dr. John Hopkinson, F.R.S., and Mr. Beauchamp Tower. The four entries comprised one steam engine and three gas engines. The first was a compound semi-portable engine of eight nominal horse-power, by Messrs. Davey, Paxman and Co., of Colchester, the engine having cylinders 5·24 and 8·98 inches in diameter, and stroke of 14 inches, the mean boiler pressure being about 190lbs. per square inch. The gas engines were the "Otto," entered by Messrs. Crossley Bros.; Atkinson's "Cycle" engine, entered by the British Gas Engine and Engineering Company, London; and the "Griffin" gas engine, entered by Messrs. Dick, Kerr and Co., London. The "Otto-Crossley" engine was nominally of nine horse-power, with a cylinder of 9·5 inches diameter, 18 inches stroke, and making about 160

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revolutions per minute. It was of the well known "Otto" type, but was fitted with a tube igniter instead of the slide valve usually employed in this engine, and, moreover, it had a counter shaft carrying a fly-wheel and running in bearings attached to the engine bed-plate itself. The object of this addition was to obtain a greater regularity of speed. As the "Otto" engine receives but one impulse in two revolutions, something of this kind is essential, but of course it takes power to work it. The Atkinson engine is of that remarkable design which, with one crank, gives four strokes of the piston for one revolution of the fly-wheel, and these strokes are of varying length. The stroke which takes the charge into the cylinder is 6·3 inches, the next stroke compresses that charge, and is 5 inches in length, the charge being thus compressed into a space of 1·3 inches. The compression being effected, ignition takes place, giving the working stroke, which is 11·13 inches in length. This stroke is followed by the exhaust stroke, which sweeps the products of combustion out of the cylinder, and is 12·4 inches in length. The cylinder is 9·5 inches in diameter. It will thus be seen that with this engine the two most important elements essential to economical working are obtained, namely, compression of the charge to whatever pressure may be desired, and a large range of expansion. In the engine tested the exploded charge was expanded to more than double the original volume before compression. In all other engines the greatest expansion of the heated gases is equal to the original volume swept through by the piston taking in the charge, and the contents of the cylinder are never expanded to less than from 30lbs. to 50lbs. per square inch at the moment of exhaust. The Atkinson engine made about 132 revolutions per minute, and it was of six nominal horse-power. The "Griffin" engine differs again from the preceding, in that while the "Otto" has a four-cycle series of operations—that is, four strokes for every working stroke, the engine being single-acting—the "Griffin" has a six-cycle arrangement, but as the engine is double-acting an impulse is given to the crank shaft at every third stroke, or for each revolution and a-half. The cycle at each end of the cylinder is (1) drawing in charge of gas and air; (2) compressing the charge; (3) igniting and expanding charge, *i.e.*, working stroke; (4) exhaust stroke; (5) drawing in charge of air; and (6) ejecting this as a scavenging charge. The engine was of eight nominal horse-power, making about 200 revolutions per minute, and it had a cylinder 9 inches in diameter, and 14 inches stroke.

Such, then, are the leading features of the four engines which remained for trial. Now, we may ask, as these awards were offered for engines specially suited for small electric lighting installations, what were the questions to be asked, what were the tests to be made, or, in brief, what are the requirements? It may be assumed that for this, as for most applications of power, the cost of the power may stand as the first question; the second must be uniformity in the number of revolutions per unit of time; the third must be freedom from the necessity for stoppages other than those required by the electrical demands; fourth, good design and workmanship, and therefrom durability; fifth, first cost; and sixth, cost of maintenance. The report of the judges gives us answers to most of these questions. It gives, also, a great deal of information which is, firstly, of interest to the technical educationist, and secondly, to the makers of engines, though the latter will probably continue to go to their own workshops for information. To put the main results before our readers without following the report into the thermo-dynamic considerations to which the examination of the figures and diagrams lead the judges, will occupy very little space. Taking the names of the makers in the alphabetical order, we have first the Atkinson "Cycle" engine. The gas used per indicated horse-power amounted to 18·8 cubic feet, and per brake horse-power 22·1 cubic feet per hour. The gas used for ignition was 4·5 cubic feet per hour, making the total consumption per indicated and per brake horse-power 19·2 and 22·6 cubic feet respectively. The cost of lubrication was equal to the cost of about 1·59 cubic feet of gas. The engine ran with great regularity, as will have been expected from the fact that not only did the crank get one impulse for every revolution, but the arrangement of the connecting gear between the piston and the crank is such than when the heavy pressure is at first generated by the explosion, only a small proportion of it comes directly upon the crank, the proportion becoming greater as the pressure falls with expansion. The mechanical efficiency of the engine reached 85 per cent., and 25·5 per cent. of the whole of the heat generated was converted into work. The judges speak highly of the economy of this engine, of its regularity of speed, and of the mechanical arrangement.

Taking the same figures for the Crossley engine, which worked at 17 horse-power, we have gas per indicated horse-power 20·55 cubic feet per hour, per brake horse-power 23·87 cubic feet. With the ignition gas added these figures become 20·76 and 24·1 cubic feet per horse-power. These are, however, for the engine only, and do not take into consideration the counter-shaft and fly-wheel which Messrs. Crossley find it necessary to add in order to obtain that regularity of speed which is desirable. The actual consumption of gas, then, including, or rather not deducting this, is for the Crossley engine 27·4 cubic feet per brake horse-power available for electric lighting. The cost of lubricant was equal to that of 1·54 cubic feet of gas per indicated horse-power per hour. The engine converted 22·1 per cent. of the whole of the heat generated into work. Thus, although the well-known excellence of design of this engine and its known durability and steady working secured it a medal, it is not quite so economical as the Atkinson engine, especially when the total gas necessary to drive the second motion shaft and engine is taken into account.

The "Griffin" engine used 22·6 cubic feet of gas per indicated and 28 feet per brake horse-power per hour; with the ignition gas added this reached 22·64 and 28 cubic feet per hour. The lubricant cost the same as 2·72 cubic feet of gas per horse-power per hour. The engine converted into work 21·1 per cent. of the whole of the heat generated. The indicated horse-power of the engine was 15·47, and the brake horse-power 12·5, the mechanical efficiency being thus 80·9 per cent. This engine ran very steadily and uniformly, and from the figures given it will be seen to have been next to the Atkinson engine in economy per horse-power available for electric lighting.

The last engine is the steam engine of Messrs. Davey, Paxman and Co. The results arrived at with this engine confirm in a remarkable degree those obtained by a similar engine by the same firm at the Newcastle trials of the Royal Agricultural Society in 1887. The engine used only 20·74lbs. of steam per indicated horse-power, and 23·08 per brake horse-power. The coal consumed was as low in one trial as 1·79lb. per indicated horse-power, and 2·04lbs. per brake horse-power per hour. The brake used was the rope brake, which the judges say is above suspicion; and hence the cavil which we remember was rather loudly raised against the Newcastle results turns out to be groundless. The engine worked at 19·44 brake horse-power, the indicated power being 22·12, the mechanical efficiency being thus 88 per cent.

In round numbers, then, we may now conclude that it is possible to have a brake horse-power hour from a gas engine for 22·61 cubic feet of gas, including all consumption, or if at 3s. per 1,000, the cost would be 0·8 of a penny per brake horse-power hour. From a compound steam engine we may

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get the same power, 0·218 of a penny per brake horse-power. These are the results as far as cost of fuel is concerned, and from the remarks of the judges it is clear that any of the engines can be trusted for good continuous work.

REVIEWS.

Le Compteurs d'Energie Électrique. By E. Hospitalier. (Reprinted from *L'Electricien.*) (Paris: G. Masson, 1889.)

At a time when the electricity meter is the subject of so much discussion, the appearance of this little *brochure* is decidedly opportune, although it will, we think, be found that with scarcely an exception the instruments selected for description are either already well-known in this country, or else they are of but little practical importance. Altogether, some eighteen different types are described and illustrated.

Neglecting the mere counters of time (which are nothing more than clock-trains started and stopped as the current is switched on and off), we have first the class of coulomb meters, beginning with the well-known Edison electrolytic cell. M. Hospitalier does not like this type of meter, and in spite of Prof. Forbes's recent certificate we think that his views will find general acceptance in this country. The author's remarks upon this subject are worth quoting. He says:—"The employment of this meter presents some considerable practical difficulties, since it is necessary to change the solution at frequent intervals, and to wash, rinse, dry and carefully weigh the plates, at the house of the client. These troublesome operations (*manipulations fastidieuses*) not only increase the cost of working, but they also fail to give satisfaction to the consumer, and oblige him to rely on the good faith of the company." Mr. Jenks has, however, recently told us that in practice all these difficulties have been completely overcome. We are glad to learn this, but it does not tend to shake our opinion that, other things being equal, a meter which can be read by inspection is to be preferred.

The Ferranti meter is next described, although not so fully as in *The Electrician* of Nov. 23, 1888, p. 71, or by Prof. Forbes in his recent Lecture at the Society of Arts (*Electrician*, Feb. 1, 1889, p. 374). Next we have the Lippmann meter, which is based upon the singular electro-capillary phenomena which M. Lippmann has already turned to good account in other ways. The meter consists essentially of a small rectangular chamber filled with mercury, and lying between the poles of a permanent magnet. The current to be measured passes through the mercury in the chamber. The latter is connected on one side with a reservoir of mercury, and on the other with a tube open at the end, which is curved round and bent over the reservoir. When the current passes the effect is to drive the mercury from the chamber along the curved tube, whence it falls back into the reservoir, thus keeping up a continuous flow, which is proportionate to the current so long as the field is constant. The recording apparatus consists of a balanced trough, divided into two compartments, which tilts to one side or the other as soon as either compartment is filled with mercury. This movement is caused to act on a wheel train in the usual manner. The principle of the instrument is of great scientific interest, but it has never come into actual use. M. Hospitalier says he is not aware of the reason for this neglect, but it is easy to guess that the constant fall of mercury through air results in a considerable loss by oxidation, and also that the presence of the oxide interferes with the freedom of the action. We do not, however, regard this difficulty as insuperable.

The instrument next described is that devised in 1887 by Dr. Werner Siemens. In principle it is identical with the Hookham meter, described in our issue of Feb. 1, 1889, p. 369, but the details are widely different. In each case the measurement is effected by the rotation in a magnetic field of an armature, which is at the same time retarded by the generation of Foucault currents in conducting masses attached to or forming part of it. M. Hospitalier says of the Siemens meter that its proportionality is satisfactory save at the *debut*. This difficulty has been most successfully overcome by Mr. Hookham, whose meter we have seen running at the rate of ten or a dozen turns a minute, and, as we have been assured, without loss of proportionality.

The author next gives an appreciative description of the Forbes meter. He raises a sound but somewhat academic objection to the use of the term coulomb-meter in this connection, on the ground that what the Forbes meter really measures in the case of alternating currents is the square root of the mean square of the currents. This is, of course, just the thing which we want to measure, though it is quite true that it does not represent the coulombs.

After describing the Shallenberger* and the Aron† meter in its latest form, M. Hospitalier refers to an ingenious idea due to Mr. Vernon Boys, which was exhibited so long ago as 1882 at the Crystal Palace Exhibition. The principle involved is briefly that of a horizontal pendulum, or balance wheel, in which the office of the weight, or spring, is supplied by the current to be measured.

The succeeding ten pages are devoted to the Cauderay meter, which ingenious instrument apparently lacks nothing but simplicity of design and construction to render it at least as near an approach to perfection as any other at present in the field. It is, however, difficult to believe that so complicated an apparatus, no matter how beautiful in conception, can compete successfully with some others that might be named. The author makes use of no less than 15 diagrams to describe the three slightly modified types which the inventor has brought out. It must, however, be admitted that though the Cauderay meter has so far met with little success in this country, it appears to do much better in France; indeed, this and the Brillié are the meters now chiefly in vogue in that country. We shall come to the Brillié presently, but we may add here that although it is nearly as complicated as the Cauderay, yet in point of price neither of them compare with others so unfavourably as might perhaps have been supposed.

The author next turns his attention to volt-hour-meters, and he, of course, points out that nearly every meter hitherto described may be adapted to measure volt-hours instead of coulombs. He speaks approvingly of Mr. Wright's use of the depositing cell at Brighton as a shunt on a constant-current circuit (see *Electrician*, December 16, 1887, p. 128), where, of course, it is not open to the same objections as in the case of the chemical coulomb-meter. Mr. Wright, it may be remembered, causes the increasing weight of the deposition plate to move a needle over a divided scale. M. Hospitalier, who is a great purist in the matter of units and nomenclature generally, "protests energetically" (and characteristically) against the barbarous graduation of Mr. Wright's scale in Board of Trade units. We suppose that his excuse would be that his customers know the price they have to pay per B. T. unit, and hence the graduation is such as they can easily appreciate. In fact, we have little doubt that the only reason why Mr. Wright does not graduate his scale in pounds, shillings and pence is because the present tariff may some day be revised; and for our own part we should not be greatly distressed if this graduation were adopted.

We now come to the final division, which comprises the watt-meters. The Weston type is first alluded to, but if we mistake not this instrument has not yet been perfected. The Aron meter, with a shunt coil on the pendulum bob enclosing a solenoid which carries the main current, and another early design of Mr. Vernon Boys, are described and illustrated. Then we come to the Brillié meter of 1888. This instrument has almost as much space devoted to it as the Cauderay, and, as has already been said, it almost equals the latter in complexity. It would be difficult to give an intelligible account of the construction without the aid of diagrams, but our readers may obtain some idea of the instrument from the following quotation:—"The principle of the discontinuously integrating energy meter of M. Brillié consists in ascertaining at regular intervals the reading of a suitable wattmeter, and of integrating the indications so obtained; the action, which is entirely automatic, depends upon the oscillations of a pendulum, the periodical

* *Electrician*, Sept. 7, 1888, p. 556, and Feb. 8, 1889, p. 394.
† *Electrician*, Feb. 15 1889, p. 438.

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reception of the indications, the movement of the integrator, and the return to the position of rest between two successive operations. The mechanism consists of five principal organs:

"1. An *electro-dynamometer* indicating the power E I which the consumer is employing at the instant of measurement:

"2. An *electro-motor* which drives the whole apparatus:

"3. A *moderator* which regulates the various movements:

"4. A *clock-work train* which determines the interval of time between each successive action:

"5. A *numerator* or *integrator* which registers the sum of the successive values of E I taken at sensible equal periods of time."

Such is the meter of M. Brillié! In the early patterns the record was made at every 36 seconds, but the interval is now increased to one minute.

ON THE DESIGNING OF CONTINUOUS-CURRENT DYNAMO MACHINES.*

BY PROF. JAMIESON, M.INST.C.E., F.R.S.E.

In the short time at the disposal of the author, he proposes to confine his remarks and calculations to "Continuous-Current Constant-Pressure Compound Dynamos," as now used for supplying current to ordinary incandescent lamps arranged upon the parallel system. . . . It is not our intention to enter here into the many mechanical and electrical arrangements of dynamos, or to trace the manner in which dynamos have been gradually simplified and cheapened. . . .

Let E_a represent the electrical pressure generated in the armature.
E_e ,, external electrical pressure, or that available for useful work.
R_i ,, internal resistance of the whole dynamo.
R_e ,, external resistance of leads and lamp circuits.
C_a ,, current passing through armature.
C_e ,, current external, or that sent through lamp circuit.

Then, $$C_a = \frac{E_a}{R_i + R_e} = \text{total current generated.}$$

And, $$C_e = \frac{E_e}{R_e} \text{ external current.}$$

The electrical efficiency $= \frac{C_e \times E_e}{C_a \times E_a} = \frac{\text{output in watts}}{\text{total watts generated}}$.

Now, since C_a, E_e, and C_e depend directly upon E_a, we propose to show how this internal electrical pressure may be obtained for any dynamo of the kind under consideration.

This total or internal pressure, E_a, depends entirely upon—

1. The total number of magnetic lines which flow between the field-magnet poles through the armature.
2. The total number of convolutions of the armature conductors which are in series at one time.
3. The speed of rotation of the armature.

The *number of revolutions* per minute is a matter that can be easily decided upon before beginning to design the dynamo. Fast speed dynamos, if well balanced, are common in land installations; slow speed ones on board ship, and when vibration and noise must be avoided.

The *number of convolutions* of the armature conductor depends upon the number of radial bars in the commutator, the diameter of the armature, and the size of wire to be used, all of which will be determined as the drawing or design proceeds in accordance with sound practice.

The *magnetic circuit* is the chief and most intricate part of the whole design which requires our attention, and we shall therefore consider it first in full detail.

I.—*Field-Magnet Circuit.*

The field-magnet circuit should have as little magnetic resistance as possible. The magnet cores, &c., *should* therefore be made of the best soft Swedish iron, short, of large sectional area, and with no joints. Owing, however, to expense, the difficulty of winding the wire on the magnets, or the fixing of bobbins containing the wire, and the necessity of having sufficient residual magnetism with which to start the dynamo current, and to prevent fluctuations of current, the yoke (if there is one) and the pole-pieces are frequently made of cast iron.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, on 22nd January, 1889.

In a Kennedy dynamo (*see* Fig. 1), the mean length of the magnetic circuit indicated by the letter L_m, and the poles are marked N and S.

II.—*Air Spaces.*

The air spaces should have the least possible magnetic resistance. They should therefore have as little depth as is consistent with preventing actual contact between the armature wires and the pole-pieces, and of allowing free circulation of air, and of preventing heating of the pole-pieces due to Foucault or eddy currents in the forward ends of the pole-pieces.

In Fig. 1 the two air spaces are marked L_{as}, L_{as}.

III.—*Armature Core.*

The armature core should have as little magnetic resistance as possible, and be as free as possible from inducing Foucault currents. It should therefore be built up of the softest thin Swedish iron plates, well insulated from each other, and laminated or placed in a direction parallel to the direction of the magnetic lines passing between the poles of the field-magnet. Some makers prefer to build up their armature cores of soft iron wire insulated by the natural thin coating of oxide of iron always found on such wire.

In Fig. 1 the mean directions of the split magnetic circuit through the armature core are marked L_a, and L_a.

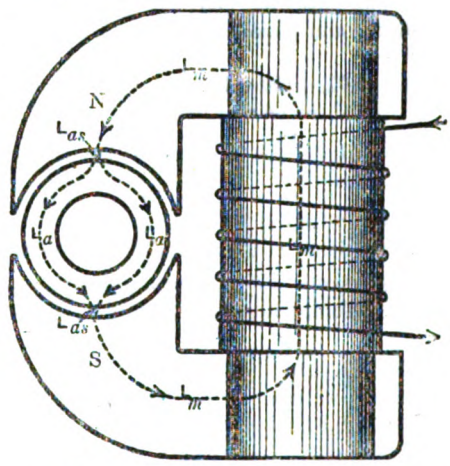
IV.—*Magnetic Resistance of Field-Magnet Circuit.*

The magnet circuit L_m has a magnetic resistance

$$R_m = 2\frac{L_m}{S_m},$$

where

2 = Kapp's coefficient for the initial specific magnetic resistance of soft wrought iron (the number 3 to be used if core, &c., be of cast iron).
L_m = the mean length of field-magnet circuit in inches.
S_m = sectional area in square inches (at right angles to L_m) of magnet core.



Magnetic Circuits of a Single-Bobbin Kennedy Dynamo.

V.—*Magnetic Resistance of Air Spaces.*

The air spaces circuits L_{as}, L_{as} have a resistance

$$R_{as} = 1440\frac{2\,L_{as}}{S_{as}},$$

where

1440 = Kapp's coefficient for the specific magnetic resistance of air and copper when wrought-iron magnets are used (1800 to be used with cast-iron magnet cores and pole-pieces, and 1500 with wrought-iron cores and cast-iron poles).
L_{as} = depth of each air space in inches (and since there are two spaces, 2 L_{as} is inserted in the formula).
S_{as} = sectional area of each air space or surface area of each pole-piece in square inches.

VI.—*Magnetic Resistance of Armature Core.*

The armature core circuits L_a, L_a have a magnetic resistance

$$R_a = \frac{L_a}{S_a},$$

where

L_a = mean average length of armature core magnetic circuit in inches (if there was only but one path instead of two we should have to multiply by the coefficient 2, as in equation (IV.), but $2\frac{L_a}{2} = L_a$).

S_a = cross sectional area of armature core in square inches = twice radial depth × length of armature core

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VII.—*Total Magnetic Resistance.*

The total magnetic resistance of the complete magnetic circuit is therefore—

$$R_m + R_{as} + R_a = 2\frac{L_m}{S_m} + 1440\,\frac{2\,L_{as}}{S_{as}} + \frac{L_a}{S_a}.$$

VIII.—*Kapp Lines.**

The total number of Kapp lines, K, of magnetic force which pass through the magnet and air space can therefore be calculated by *dividing* the ampere-turns ($A \times T_{mw}$) on the magnet windings by the total magnetic resistance in the magnetic circuit.

Or
$$K_L = \frac{A \times T_{mw}}{R_m + R_{as} + R_a},$$

i.e.,
$$K_L = \frac{A \times T_{mw}}{2\,\frac{L_m}{S_m} + 1440\,\frac{2\,L_{as}}{S_{as}} \times \frac{L_a}{S_a}}.$$

IX.—*E.M.F. in Armature.*

The E.M.F. developed internally in the armature winding is—

$$E_a = K_{La} \times T_{aw} \times N_{ar} \times 10^{-6},$$

where

E_a = E.M.F. developed in armature in volts.
K_{La} = Kapp lines which only pass through armature or the useful field.
T_{aw} = turns of armature wires in series (counted all round core).
N_{ar} = number of armature revolutions *per minute*.

Example I.†—Let us now apply the foregoing formulæ to the design of a single-field compound dynamo.

Let the dynamo be furnished with a long shunt, and be of 6,400 watts (external power, P_W), when driven at 1,000 revolutions per minute.

First, let us determine the resistance, current, fall of potential, in armature and magnets, and percentage loss of power in the armature, shunt, and main field-magnet coils, using the same symbols as before.

Given $E_e = 100$ volts.
$C_e = 64$ amperes.

Resistances—Then $R_e = \frac{E_e}{C} = \frac{100\,v}{64\,a} = 1{\cdot}55$ ohm.

Suppose we agree to a loss of about 10 per cent. of the total power in the dynamo, or say—

The electrical efficiency of the dynamo = 90 per cent.

$\therefore$ 90 per cent. : 100 per cent. :: 6,400 P_W : x.

$\therefore$ Total power = x = 7,100 P_W.

Let $R_a = \frac{R_e}{20} = \frac{1{\cdot}55}{20} = {\cdot}077\ \omega.$

Let $R_s = R_a \times 1{,}000 = {\cdot}077 \times 1{,}000 = 77\ \omega.$

Let $R_m = 75\%\ R_a = \frac{3}{4} \times {\cdot}077 = {\cdot}058\ \omega.$

Now, the external current = current in armature and field-magnet main coils less the current in shunt.

Currents.—Or $C_e = C_a - C_s.$

But, $C_s = \frac{E_e}{R_s} = \frac{100v}{77\ \omega} = 1{\cdot}3\,a;$

$\therefore$ $64\,a = C_a - 1{\cdot}3\,a,$

$C_a = 64 + 1{\cdot}3,$

$= 65{\cdot}3$ amperes.

Fall of potential in armature $= C_a \cdot R_a = 65{\cdot}3 \times 0{\cdot}77.$

$= 5{\cdot}02$ volts.

Fall of potential in magnet main coils $= C_m \cdot R_m = 65{\cdot}3 \times {\cdot}058$

$= 3{\cdot}78$ volts.

Total fall of potential in armature and magnet series coils.

$= C_a$ or $C_m\,(R_a + R_m)$

$= 65{\cdot}3\,({\cdot}077 + {\cdot}058) = 8{\cdot}8\ v;$

$\therefore$ $E_a = 8{\cdot}8 + E_e = 108{\cdot}8$ *volts.*

Percentage losses of power.—

In armature $= C_a^2 \cdot R_a = 65{\cdot}3^2 \times {\cdot}077$

$= 330\ P_W;$

$\therefore$ 7100 P_W : 330 P_W :: 100 : x_a.

$x_a = 4{\cdot}63$ per cent.

In shunt coils $= C_s^2 \cdot R_s = 1{\cdot}3_a{}^2 \times 77\omega$

$= 132\ P_W;$

$\therefore$ 7100 P_W : 132 P_W :: 100 : x_s.

$x_s = 1{\cdot}86$ per cent.

In main coils $= C_m^2 \cdot R_m = 65{\cdot}3^2 \times {\cdot}058$

$= 248\ P_W;$

$\therefore$ 7100 : 248 :: 100 : x_m.

$x_m = 3{\cdot}5$ per cent.

Totalling the different percentage losses we have :—

In armature..... $x_a = 4{\cdot}63$ per cent.
In shunt coils..... $x_s = 1{\cdot}86$,,
In main coils ..... $x_m = 3{\cdot}5$,,

$9{\cdot}99$ %, or, say, 10 %.

Kapp Lines in Armature Core.—Now, before substituting the above data in Kapp's formula, we must agree upon the turns of wire in the armature at the agreed upon 1,000 revolutions per minute. Let there be 36 commutator bars of 36 sections of wire in armature, which has been found sufficient to give a current of practically uniform E.M.F. The number of turns of wire in each section of the armature depends upon whether we use double or single winding, and upon the current and the resistance of the armature wire. As we shall see further on, from our trial drawing and calculations we can get in six turns of wire to each section.

$\therefore$ $T_{aw} = 36 \times 6 = 216$ turns of armature wire.

Let $N_{ar} = 1{,}000$ revolutions per minute.

Now $E_a = K_L \times T_{aw} \times N_{ar} \times 10^{-6}.$

$\therefore$ $K_{La} = \frac{E_a}{T_{aw} \times N_{ar} \times 10^{-6}}.$

$= \frac{108{\cdot}8\ v}{216 \times 1000 \times 10^{-6}} = 503{\cdot}7,$

say = 500 Kapp lines in *armature core.*

In order to obtain a certain number of Kapp lines or magnetic induction in an armature, core it is necessary to give a greater magnetic intensity to the field-magnet core or cores, owing to the unavoidable leakage of magnetic lines which do not pass through the armature core.

Dimensions of Magnet Core.—In ordinary practice it is usual to assume that only about 80 per cent. of the field-magnet lines pass through the armature core.

Therefore, the Kapp lines in *field-magnet* are—

80 per cent. : 100 per cent. :: 500 : $x = 625$.

We must now ascertain the dimensions of the field-magnet core to carry these 625 Kapp lines. Suppose we consider the case of field-magnets to be cast iron throughout (poles and core).

A safe working density is 9 Kapp lines per square inch

$\therefore$ $S_m = \frac{625}{9} = 69{\cdot}4$ square inches.

$= 9{\cdot}4$ inches diameter (if round).

In practice it is found that a dynamo magnet bobbin should be in length about $1\frac{1}{4}$ times its diameter to give the necessary space for winding or ampere-turns.

$\therefore$ $9{\cdot}4 \times 1{\cdot}25 = 11{\cdot}75$ inches long.

Dimensions of Armature Core.—It has been found advisable, in designing the dimensions of the armature core of a dynamo having a field-magnet of the form we are now considering, to make the diameter of its core slightly larger, and its length slightly less, than the diameter of the field-magnet core.

Therefore, calling the diameter of the gramme armature core 10 inches, its length 9 inches, and allowing a density of 20 Kapp lines per square inch of core section, since it is made of the best permeable wrought iron,

we have $\frac{500}{20} = 25$ square inches total cross section of armature.

$\therefore$ $S_a = 25$ square inches.

Allowing 20 per cent. of total space for insulation between *laminated plates* in armature core, we have

80 per cent. : 100 per cent. :: 25 : $x = 31{\cdot}5$ square inches;

$\therefore$ $\frac{31{\cdot}5}{2} = 15{\cdot}75$ square inches in each half.

$\therefore$ $\frac{15{\cdot}75}{9''} = 1{\cdot}75$ inch = radial depth of core.

* A Kapp line is simply = 6.000 C.-G.-S. magnetic lines.
The number 6,000 is made up of two terms, viz., 60, which enables revolutions to be counted per minute instead of per second; and 100, to bring down the measurement of the magnetic lines to reasonable numbers; or $\frac{\text{C.-G.-S. lines}}{60 \times 100} = \frac{\text{C.-G.-S. lines}}{6000}$. Then, 1 Kapp line = 6,000 C.-G.-S. lines.
Since there are 6·4514 square centimetres in a square inch,
1 Kapp line per sq. inch = $\frac{6000}{6{\cdot}4514} = 930$ C.-G.-S. lines per square centimetre.

† The calculations for Example I. were made by Boucher's Calculator, and thus are therefore only approximately true.—A. J.

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Magnetic Resistance of Field-Magnet.—Now, drawing armature and field-magnets to scale (as per Fig. 1), and allowing 2½ inches for depth of winding on field-magnet bobbin and clearance for armature, we find the mean length of field-magnet core $L_m = 44$ inches, and remembering that in a formula for the magnetic resistance of this part of the circuit we have to use a coefficient of 3 instead of 2, seeing that the core is of cast iron,

we have
$$R_m = 3\frac{L_m}{S_m}$$
$$= 3\frac{44}{69{\cdot}4} = 19.$$

Magnetic Resistance of Air Space.—With *two* layers of insulated conductors having a cross-section (⌐¬) of ·08 inch deep, by ·2 inch broad (including covering), we find the total depth of air space on one side between pole-pieces and armature core (allowing ·14 inch mechanical clearance), equal ·3 of an inch.

Consequently, $2\,L_{as} = 2 \times {\cdot}3 = {\cdot}6$ inch.

The bore of pole-pieces will be = diameter of armature core + $2\,L_{as}$
= 10 inches + ·6 inch = 10·6 inches.

It is good practice to allow the corners of pole-pieces to form an angle of 30° with centre of armature. The angle embraced by each pole-piece will therefore be 180° − 30° = 150°, which gives us a circumferential length of say 14 inches for each pole. And since our armature core is 9 inches long, and it is unusual to make the pole-pieces broader than this length, we have

$S_{as} = 14$ inches × 9 inches = 126 square inches.

Hence
$$R_{as} = 1800\frac{2\,L_{as}}{S_{as}}$$
$$= 1800\frac{2 \times {\cdot}3}{126} = 8{\cdot}5.$$

Magnetic Resistance of Armature.—Referring to scale or full-size section, we find by measurement that $L_a = 15$ inches. We have already determined S_a to be 25 square inches;

consequently,
$$R^a = \frac{L_a}{S^a}$$
$$= \frac{15}{25} = {\cdot}6.$$

$$\therefore\ R_m + R_{as} + R_a = 1{\cdot}9 + 8{\cdot}5 + {\cdot}6$$
$$= 11 \text{ Kapp units of magnetic resistance.}$$

Ampere Turns.—From formula for *cast* iron, under heading VIII.

$$K_L = \frac{A \times T_{mc}}{R_m + R_{as} + R_a} = 625 \text{ (gross Kapp lines)}$$

$$\therefore\ A \times T_{mc} = K_L\,(R_m + R_{as} + R_a),$$
$$= 625 \times 11,$$
$$= 6875 \text{ total ampere-turns in shunt and main field-magnet coils.}$$

(To be continued.)

THE PHYSICAL SOCIETY.

ANNUAL GENERAL MEETING.

At the annual general meeting of this society, held on February 9, Prof. Reinold, president, in the chair, the reports of the Council and treasurer were read and adopted. From the former it appears that the number of members has only slightly increased during the year, due, it is supposed, to the advantages offered by the Society not being generally known, and a fly-leaf has been prepared, giving a short account of the Society's objects and procedure, copies of which may be obtained from the secretaries. During the past year Vol. I., Part 1, of "Physical Memoirs Selected and Translated from Foreign Sources," has been printed and issued to members; and the translations of important memoirs by Fourier, Hittorf, and Volta are well advanced, and will be published shortly. The treasurer's report showed the financial position of the Society to be very satisfactory. Owing to the lamented death of Prof. Clausius, a vacancy has occurred in the list of honorary members, to fill which Prof. R. W. Bunsen was nominated by the Council and duly elected. The following gentlemen were elected to form the new Council:—President: Prof. A. W. Reinold, F.R.S.; Vice-Presidents: Dr. E. Atkinson, Prof. W. E. Ayrton, F.R.S., Shelford Bidwell, F.R.S., the Right Hon. Lord Rayleigh, Sec.R.S.; Secretaries: Walter Baily, Prof. J. Perry, F.R.S.; Treasurer: Prof. A. W. Rücker, F.R.S.; Demonstrator: C. Vernon Boys, F.R.S.; other members of Council: Hon. R. Abercromby, T. H. Blakesley, W. H. Coffin, Conrad W. Cooke, Prof. O. Lodge, F.R.S., Prof. W. Ramsay, F.R.S., W. N. Shaw, Prof. S. P. Thompson, H. Tomlinson, and Dr. G. M. Whipple. Cordial votes of thanks were passed (1) to the Lords of the Committee of Council on Education for the use of the rooms and apparatus of the Normal School of Science: (2) to the Council and officers of the Society for their services during the past year; and (3) to the auditors, Mr. Inwards and Prof. Minchin, for examining the accounts. In returning thanks for the Council and officers the President attributed the great success of their meetings to the indefatigable zeal displayed by the Hon. Secretaries.

At the following meeting, on February 23, Prof. AYRTON gave an account of a Paper by Prof. Perry and himself on

Electrical Measurement.

The Professor observed that it is well known that the change in the resistance of a galvanometer owing to the heat produced by the passage of a current through it is of no importance when the galvanometer is used as an ammeter, but becomes of importance when it is used as a voltmeter. The authors had therefore endeavoured to determine mathematically the law according to which both the thickness and the material of the coils of their magnifying-spring voltmeter should vary with the diameter of each convolution in order that the heating should be a minimum, and the results were communicated to the Society in 1885. They found that copper wire should be used in preference to German silver wire throughout, and that the thickness of each convolution should be proportional to the radius raised to the power 0·42. Practically their magnifying-spring voltmeters are made with three or four different thicknesses of wire, as it would not be convenient to vary the thickness for every layer.

In making the calculations fairly simple laws were assumed for the variation of the magnetic effect of a convolution with its distance from the soft iron cylinder, and for the variation of the thickness of the silk covering with the thickness of the wire.

Since then the substance platinoid had been obtained, having a temperature coefficient less than half that of German silver, and some experiments on phosphor-bronze made at the Central Institution had shown that it varies its resistance only 0·08 per cent. per degree C., and that the resistance of a cubic centimetre at 0° C. is only 9·7 microhms, as compared with 1·6 microhm for copper.

The authors find that for a voltmeter wound with wire of the same gauge throughout, an approximation to the heating error can be obtained for wire of any material, of any diameter, with any thickness of insulating covering, and they find that the number of watts which must be expended to produce a given deflection is proportional to the product of the specific resistance of the material by the square of the ratio of the diameter of the covered to the uncovered wire. Now, for fine wire this ratio is greater than for thicker wire, and therefore a voltmeter wound with fine wire for the measurement of high voltages will become hotter than one wound with thick wire. They prove, in general, the fact that, as was first suggested to them by Mr. Crawley, the number of volts which must be maintained between the terminals of a voltmeter of a given type, whatever the material and diameter of the wire with which it is wound, and whatever the thickness of the insulating material, is simply proportional to the resistance per centimetre of the wire.

Let a be the coefficient of increase of resistance per degree centigrade of the wire with which the voltmeter is wound, S the cooling surface of the instrument in square centimetres, e the rate of loss of heat in watts per square centimetre per degree of excess of temperature of the instrument above that of the room, ρ_0 the resistance of the wire per cubic centimetre at 0°C. K is a constant depending on the construction of the instrument, and D and d are the diameters of the covered and uncovered wires respectively. Then the authors find that the percentage heating error due to a continued maintenance of the P.D. at the terminals of the instrument is

$$\frac{100}{\frac{S\,e}{a\,\rho_0\,K} \cdot \frac{d^2}{D^2} - 1}.$$

Consider four voltmeters exactly similar as regards size, shape and magnifying spring, wound respectively with copper, German silver, platinoid and phosphor bronze, the wire in each case being of such a diameter that the same number of volts maintained at the terminals of each instrument produces the same deflection; that is, let the resistance per unit length of each wire be the same in each case, irrespective of the thickness of the insulating covering. Then, if the diameter of the copper wire be 5 mils (thousands of an inch) the others will be

German silver ..... $5\sqrt{\frac{21}{1{\cdot}6}}$ = 18 mils nearly.

Platinoid ..... $5\sqrt{\frac{34}{1{\cdot}6}}$ = 23 mils nearly.

Phosphor bronze ..... $5\sqrt{\frac{9{\cdot}7}{1{\cdot}6}}$ = 12 mils nearly.

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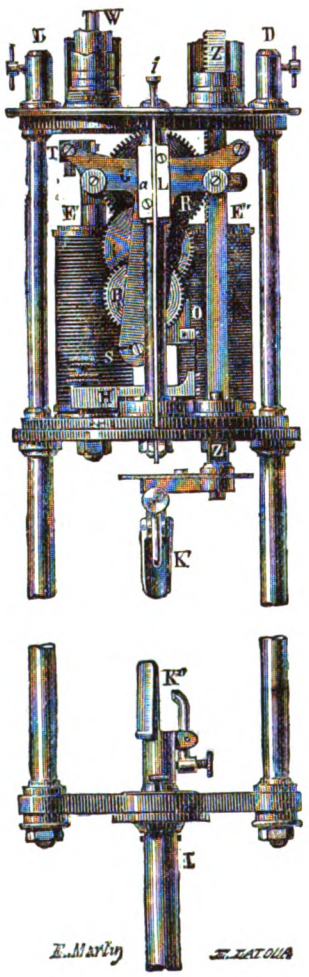
Now the authors find that for wires of diameters varying (when uncovered) from 3 to 50 mils, the thickness of the silk covering increases the diameter by about 3 mils in each case, and therefore the values of $\frac{d}{D}$ are $\frac{5}{8}$ for copper, $\frac{18}{21}$ for German silver, $\frac{23}{26}$ for platinoid, and $\frac{12}{15}$ for phosphor bronze, in order that the same voltage may produce the same deflection, and hence they find the values of $\frac{1}{\alpha \rho_0} \cdot \frac{d^2}{D^2}$ to be $6{\cdot}106 \times 10^7$ for copper, $7{\cdot}952 \times 10^7$ for German silver, $11{\cdot}21 \times 10^7$ for platinoid, and $8{\cdot}046 \times 10^7$ for phosphor bronze; so that if these substances be arranged in diminishing value for use in voltmeters as regards the heating error, they stand platinoid, phosphor bronze, German silver, copper. If, however, the range of all four voltmeters be such that a 10 mil copper wire would be the right gauge to use in the case of the copper, then the authors find that the materials arrange themselves in a slightly different order—viz., platinoid, phosphor bronze, copper, German silver, the German silver in this case being the worst metal to use.

THE FEIN ARC LAMP.*

In the Fein lamp there are two electro-magnets, E′ and E″, the cores of which are attached to the extremities of the cross-piece of the frame G, and a series of clockwork wheels arranged inside this



T-shape frame. The electro-magnet E′ is wound with thick wire, and is in series with the main circuit; the electro-magnet E″ is wound with fine wire, and is a shunt upon the arc. The frame G is supported by the plates L, and it oscillates round the axis of the wheel R, which engages with the rack Z. The rotation of the last wheel B is stopped by the brake O, which is connected to one end of a flexible strip of metal, the other end of which is attached to H. The position of H is regulated by means of the screw S. When the circuit is closed the action of the electro-magnet E′ preponderates, it attracts its core, and causes the frame G to oscillate from right to left; this brakes the wheel B and raises the rod Z, striking the arc. As the carbons consume away the action of the electro-magnet E″ becomes preponderant, the frame G oscillates in the reverse direction, and the rod Z is allowed to fall. If by any chance the arc is broken the current in the coils of the solenoid E″ attains a maximum, and the contact T is pressed against the upper plate of the lamp, completing the circuit through W, a resistance equal to the working resistance of the lamp. The remaining lamps in circuit are therefore in no way affected.

* Translated from M. Hippolyte Fontaine's "Éclairage à l'Électricité," by kind permission of the author.

LEGAL INTELLIGENCE.

King, Brown and Co. v. The Anglo-American Brush Electric Light Corporation (Limited).

The evidence of Charles Francis Brush, of Cleveland, Ohio, taken by commission in America on behalf of the defenders in this action, has now been reported to the Court of Session. He deposed that he was thirty nine years of age, and for the past twelve years had given a great deal of study and attention to electrical science. He was the person referred to in letters patent No. 2003 of 1878. He claimed to be the first inventor of the invention there described, and he communicated it to Herbert John Haddan. To the best of his knowledge and belief the invention was novel in the United Kingdom at that date. *Q.* State generally the state of knowledge in England or America as to the systems of winding the magnets of dynamo machines in 1878?—*A.* At that time dynamo electric machines were used principally for two purposes—electric plating and electric lighting by means of the arc system. Prior to the date of my invention it was customary to construct dynamo-electric machines for both of the purposes above specified on the series plan. Some of the earlier plating machines had their field-magnets excited by a separate magneto electric machine. The shunt dynamo was not then known. The state of electrical knowledge as to the construction of incandescent lamps was exceedingly crude, and no incandescence lamp of a practical or commercial nature had been produced. These prior dynamos were unsuited for incandescence lighting in parallel arc, because of their inability to maintain a substantially or sufficiently constant potential with varying amounts of work in their external circuits. They could not operate normally a small amount of work as well as a large amount of work. The object of his invention was the production of a dynamo electric machine that would automatically maintain a substantially or sufficiently constant potential under varying amounts of work in its external or working circuit. While in his specification he had quite fully described the suitability of his dynamo for operating electro-plating baths, he did not in any degree intend to limit it to such a use, and in support of this he quoted from the specification of the Haddan patent:—"It will now be obvious that if even a moderately strong magnet field be constantly maintained within the machine both of the above-described difficulties will be eliminated. Other useful applications of a permanent field machine will readily suggest themselves." It was apparent to him that his dynamo was eminently suitable for other uses than that of electro-plating, and in the language quoted he had designed to state that fact. His dynamo was of great value for incandescent lighting, because of its ability to maintain automatically a substantially and sufficiently constant electromotive force, and to automatically and normally do varying amounts of work, from great to small, upon its external or working circuit. To successfully do that a constant potential dynamo electric machine, such as his patent described, and such as he believed he had successfully produced for the first time, was necessary. *Q.* When did a demand for machines with constant electromotive force first spring up.—*A.* The want of such machines was felt prior to my invention, and it was the recognition of this want that led me to produce the invention. Promptly after, and continuously since, the production of his constant-potential dynamo there had been an active demand for such machines. The active commercial demand for constant potential dynamos could not be said to precede their existence, and he should say that the demand for these machines first sprang up after his invention. He first began to make machines according to his specification in the latter part of 1876 or early in 1877, and continuously since that time the Brush Electric Company of Cleveland, Ohio, had supplied the market demand for such machines. He had made many tests of the machines made by him, and on August 4, 1882, he sent to Mr. Swinburne definite reports and data of tests made prior to that date. The data were made as follows:—

No. 7 Machine.—Speed 800 revolutions per minute.

Current. Amperes.	E.M.F Volts.
13·9	87·57
44·3	90·09
73·3	88·83
93·4	80·64
100·1	67·2

No. 5 Machine.—Speed 865 revolutions per minute.

2·7	147·55
4·2	149·3
5·7	151·9
8·8	149·12
10·8	150·10
17·2	149·64
19·5	141·57
22·3	110·34

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No. 2 Machine.—Speed 1,180 revolutions per minute.

Currents. Amperes.	E.M.F. Volts.
3·6	22·64
7·15	24·38
17·8	22·78
24	22·56
26·7	20·8
27·6	16·56

Witness gave the records of other tests made in December, 1884, with incandescent machines. He could not give the exact number of his dynamos that had been sold up to the present time, but it reached many hundreds.

The witness was then asked to explain the action of the double winding, which he did at some length. Continuing, he said that he now made dynamos for lighting in parallel and in "shunt series" or compound-winding. The requirements for electro-plating were analogous to those of incandescent lighting in parallel. He believed the directions in the specification describing his invention were abundantly sufficient to enable any workman reasonably skilled in the art to which that invention appertained at the date of the Haddan patent to have made and practised the invention without the exercise of anything more than ordinary mechanical ingenuity on his part. He had carefully examined Varley's patent, No. 4,9[illegible]5 of 1876, and he did not find disclosed therein anything which at the date of the Varley patent would suggest to a skilled workman the arrangement and connection of field coils now known as compound-winding, and specifically shown and described in the Haddan patent. Being specially referred to a portion of the Varley patent, which stated that there were several ways of diverting "part of the electricity developed by the machine to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light," witness said the only well-known way, so far as he was aware, at the date of the Varley patent of energising the field-magnets of a machine aside from the use of a separate and independent current for that purpose, was by putting them directly into the circuit of the armature and external work. The writer in what had been quoted might have intended to express the idea that a part of the electrical energy developed by the machine was used to maintain the magnetism of the field-magnets, while the remaining portion of the electrical energy was used to do external work, that was to operate an electric light; but that theory of the meaning of the lines was not compatible with other portions of the specification. The writer said:—"But the method I prefer is to wrap the soft iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of larger resistance is always closed, and the circuit of less resistance is used for the electric light." In the light of their advanced knowledge of dynamo electric machinery at the present date these words might be said to hint at what was known as a series-shunt winding; but considered in the light of the state of the art which obtained at the date of the Varley specification, they might mean that or several things. The drawings, in fact, showed simply a series winding. In the Varley patent the writer says:—"When we use four electro-magnets we employ two commutators and four bobbins. Two of these bobbins and one commutator are arranged on the axle at right angles to the other bobbins, and commutator and electro-magnets are wrapped with a double series or convolutions of silk or cotton-covered wire, insulated from one another. One set of convolutions of insulated wire of the four pairs of electro-magnets is connected to one commutator, and the other set is connected to the other commutator." The writer there had evidently in view a double-series machine—that was, a machine producing from one armature two distinct currents, each having its own commutator, and each current energising a separate set of field coils on the magnets. The reason for the arrangement as to the bobbins was sufficiently obvious. Each pair of bobbins produced what was known as an alternating current, the alternations of which, being corrected by the commutator, produced a pulsating current—that was, a current consisting of waves or pulsations rising from nothing to a maximum, and quickly dropping to nothing again, and so on. Such pulsating current was not well adapted to energise field-magnets, because the magnets partially demagnetised themselves between the current pulsations. By means of the arrangement of the two pairs of bobbins at right angles with each other, the maximum strength of each pulsation of one of the currents produced by the machine would occur at a point of time between the corresponding periods of the other current, and would thus, so far as the excitation of the field-magnets was concerned, bridge over the gap, so to speak, in the other pulsating current, and render the resultant magnetising effect of the two currents more nearly uniform than would be possible with either current separately. It seemed to him a possible explanation of the language in Varley's patent might be that the writer intended to secure a machine, with its commutators and armature bobbins so arranged as to produce two separate and independent currents, one of which was caused to flow through the magnet circuit of low resistance and the arc lamp external to the machine, and the other of which was caused to flow through the magnet circuit of higher resistance and the helices of the lamp motor external to the machine. At the date of Varley's patent there were several well-known ways of diverting a portion of a current for one purpose, and at the same time using the remainder of the current for another purpose. So far as he recollected, the methods of diverting a part of a dynamo-current to excite the field were those of Ladd and Wilde, by the employment of separate armatures; also by Wilde's method of employing some of his armature bobbins to excite the field, and Rhumkorff's double-wound armature. Clark also, in his patent, No. 4,311 of 1875, indicated a form of simple-shunt dynamo, which also fulfilled the purpose suggested. Even at the present time there was only one known method of compounding a machine. He considered the so-called "long-shunt" and "short-shunt" as being but slightly differing modifications of each other. In the drawings of the Varley patent he found no indications of the way in which the wire of greater resistance was to be connected. There was only one wire, and that in series with the armature, and arranged to carry the whole current of the machine. It appeared to him that Varley's "wire of greater resistance" was intended to do work outside of the machine, that work consisting in operating the electro-motor of the lamp mechanism.—*Q.* Is that consistent with compound winding?—*A.* It might be if Varley's fine wire circuit external to the machine was kept constantly closed and of constant resistance, and his lamp motor worked with a constant load. The language of the Varley patent seemed to him more consistent with some arrangement of circuits other than compound winding. It appeared to be the fact that Varley cut his bobbins out of the circuit for a considerable time when they were acquiring or losing a very considerable amount of magnetism. The effect of that would be to produce violent sparking, and would, in his opinion, be quite fatal to any practicability which the machine might otherwise have. Varley's improvement appeared to have been founded upon a misconception of the principles involved in the generation of currents in dynamo-electric machines, and witness did not see how, under any circumstances, his apparatus, as described in the specification, so far as it was intelligible, could have been in any sense a practical or useful one. He considered Varley's patent, taken as a whole, to be so ambiguous, incomplete, and uncertain as to be impossible of any satisfactory or consistent explanation. He did not consider Varley's machine an improvement of any value upon any form of dynamo in existence at the date of his patent. There was nothing in Varley's patent to show that his two wires were intended to act simultaneously, and to augment each other's effect on the magnets. The object of the insulating segment in witness's commutator was to cut out of circuit at the proper time the two armature bobbins with which it was associated. That was done by simply opening the circuit of these bobbins through the agency of the insulating commutator segment, and one segment was as effective for that purpose as more than one could be; and for the sake of simplicity he used but one insulating segment for each set of armature bobbins. The advantages of thus making the commutator had especial reference to simplicity, durability, and facility of repair. By providing the detachably-attached segments the entire wearing parts of the commutator could be quickly, accurately and cheaply renewed whenever necessary without any disintegration of the machine, and without any disturbance of the permanent electrical and mechanical connections between the commutator and the balance of the apparatus. The disadvantages of the forms of commutators in use at the date of Haddan's specification resided in the necessity of more or less disintegrating the dynamo whenever it became necessary to renew the commutator segments when too much worn. Shown Clark's specification, No. 4,311 of 1875, witness said Clark's dynamo was a closed-coil armature machine, which necessitated the Gramme form of commutator, while the Haddan dynamo was of a fundamentally different type, now known as the "open-coil armature" type of machine. In detail of construction there was no similarity whatever between the Clark and Haddan dynamo. In the Paper which he read before the Royal Society on the 14th February, 1867, Sir Charles Wheatstone described as the best arrangement of his experimental apparatus what was now known as a "simple-shunt" wound machine. Wheatstone appeared to have used his apparatus in some experiments as a "series-wound" machine, and in others as a "shunt-wound" machine. In no experiment detailed in Wheatstone's Paper did he employ both systems simultaneously, or hint at the possibility of such combined employment in any form of machine. Even with their present knowledge of "compound winding," the apparatus described by Wheatstone could not be made to embody the principle of "compound winding," because Wheatstone's field-magnet was provided with only one coil of wire.

(To be continued.)

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February 16th*, 1889.

On the evening of Feb. 4th Mr. W. J. Hammer, who is so well known in connection with the work of Mr. Edison, delivered a lecture on "Edison and His Inventions," before the Franklin Institute, Philadelphia. In view of the fact that the number of Mr. Edison's inventions or patents reaches nearly 600, to say nothing of 300 that are in progress, it is not to be wondered that a large and varied field was traversed by Mr. Hammer in the course of his remarks. The difficulty of selecting the points of greatest interest was overcome most successfully, and the lecture embodied a remarkably able description of the principal Edison inventions in the field of telegraphy, telephony, phonography, electric lighting, &c., all of which were made clear by numerous illustrations and experiments. A striking and suggestive exhibition was given of the possibilities in the combined use of the telephone and phonograph, and telephone conversation, music, &c., were transmitted and recorded under varying conditions. A cornet solo was transmitted from a

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phonograph attached to the telephone in New York, and the notes could be heard as distinctly as if the phonograph had been in the same room as its auditors. This experiment was repeated three times, the same roller in the same phonograph in New York being used to show that the instrument could repeat itself indefinitely. The third performance was as successful as the first. Then a phonograph was attached to the telephone at the Philadelphia end of the line and a New York phonograph a fourth time repeated its cornet solo, the telephone receiver being held within a few inches of the long funnel which carried the sounds into a phonograph on the table. The Philadelphia phonograph then reproduced the music for the benefit of the audience, and while the sounds were somewhat fainter than when heard from the telephone, they were still distinct. This was a reproduction of music at fourth hand. First it had been played into the New York phonograph, then transmitted over the telephone to the phonograph in Philadelphia, and then given to the audience. This wonderful experiment was accomplished by means of two phonographs, two Edison carbon transmitters, and two Edison motograph receivers or loud-speaking telephones acting through 103 miles (the distance between New York and Philadelphia) of telephone wire, six miles of which were underground.

A most instructive and interesting meeting of the New York Electrical Society was held in the evening of February 6, when the Society visited the factory of the C. and C. Electric Motor Company, in this city, on the invitation of the company. The American Institute of Electrical Engineers were the guests of the Society, and over 150 persons were present. Mr. Harvey L. Lufkin embodied in a short address a description of the working of the factory, which being a new departure in the application of power has attracted great attention here. In the course of his remarks Mr. Lufkin said: "Our average load on the dynamo, which is a 50,000 watt machine of 220 volts E.M.F., is about 40 amperes, or about 12 electrical horse-power, which covers both light and power. The friction load on the engine is 6·4 horse-power, giving us a total of about 20 to 22 horse-power in the engine. The power which would be necessary to operate our factory in the usual way, by belting through the floors, was estimated by several engineers competent in factory construction to be between 30 and 50 horse-power, without considering the power required for our lights, amounting to an additional 15 horse-power; in other words, we are delivering an estimated 50 to 70 horse-power, and only developing from 15 to 30 horse-power, with an average of but 17 to 18 horse-power for ten hours. Every machine on our factory bears exactly this relation to the engine. Multiply the quarter horse-power saved in one machine, supposing it to be stopped for fifteen minutes each hour, by, say, 50 machines running under the same average conditions, some requiring more and some less power, and you have a total of 12½ horse-power-hours saved each hour, or 125 horse-power-hours per day. Add this 12½ horse-power to the 18 horse-power, our average load, and we begin to approach the estimated load of our factory under former conditions of practice. To this we should add about 12 or 15 horse-power, which would be necessary to drive a line of heavy main belting through the six stories of this building, and we have a gross result of from 42 to 45 horse-power. We have wired up in the building a total of 220 lights—212 16 candle-power, four 20 candle-power, two of 32 candle-power, and two 100 candle-power. From 15 to 25 of these lights are used all day, about 150 to 175 more are used about three hours during the day. Whence comes this apparent something from nothing? I will try and explain to you. Every operator in our factory who has charge of a machine, be it a milling machine or drill press, a lathe or planer, has a certain and absolute direct and instantaneous control over the automatic valve gear on our engine in the basement through the medium of the belt-shifter on his machine. We will suppose he is using a milling machine. The piece being milled has finished its travel, and the machine is stopped by shifting the belt on to a loose pulley. A horse-power of duty has been taken off of the electric motor driving that machine, the tension on the motor belt relaxes to exactly that extent, the counter E.M.F. in the armature of the motor instantly increases, and the horse-power of current, which is no longer called for in the motor, the dynamo in the engine room ceases to generate, and the automatic valve gear on the engine immediately adjusts itself to a shorter cut-off."

As will be gathered from the foregoing, belting from floor to floor is entirely obviated, and in its place we find the wires running up from the basement from one floor to the other and connected directly with the motors. A conduit is built into the side wall, in which the conductors lie. The first floor, on which most of the armature parts are built and the winding is done, contains some 20 machines, and is operated by two motors, one of 1 horse-power, and another of 1½ horse-power. Here is also the testing room and draughting department, which contains a multitude of novel devices for the rapid testing of machines. On the next floor, on which the heavier machine work is done, some 30 machines are employed, among which are lathes, planers, drill presses, milling machines, and a large boring mill. This department is run by four motors connected to separate lines of shafting; two of these are of 3½ horse-power, and two of 1 horse-power. On first glance it seems almost incredible that machines of such small power should be capable of doing the work which is actually accomplished, but when we consider the fact that each machine individually is in operation for only a short time, even in the busiest times of work, the sum total of the power consumed at any one time is but a fraction of that required to drive all the machines simultaneously. Then, again, if it is borne in mind that the usual belting to shafting from floor to floor is done away with, it will be readily understood that the indicated load on the engine is claimed to be 50 per cent. less than would be required to operate the factory in the usual way.

The last of the seemingly endless Bell telephone infringement cases has just been decided. Judge Wallace, of the United States Circuit Court, in directing a decree for the American Bell Telephone Company in their suit against the Wallace Electric Telephone Company for infringement of patents, says that there is nothing distinguishable in essentials in that suit from those already decided by the Courts, nor was anything materially new disclosed. The Court considered that no useful purpose could be served by an extended discussion of the questions of law and fact which have been so exhaustively treated in the argument and brief of counsel for defendant, because nothing pertinent can be added to what has already been said in the previous opinion of the Courts. By this decision the construction which has been placed upon the Bell patent by the Courts is confirmed, and in all probability permanently established.

The course of trial trips with the Daft electric motor, "Benjamin Franklin," which has been proceeding daily since January 28th last, has resulted in the increased confidence of the public in electric traction and the unqualified satisfaction of the Daft Company. The tests were eminently successful. With eight empty cars in a train, making a load of 122 tons, a speed of 7½ miles an hour was obtained up a gradient of nearly two per cent., without the slightest noticeable strain upon the locomotive, although the development of energy exceeded 120 horse-power. With a four-car train, the standard for the Ninth Avenue line, carrying an average load of passengers, 15½ miles an hour were easily made up the same gradient, an excess of 2½ miles over the running time of the steam trains between stations. The "Franklin" has on several occasions attained a speed of 30 miles an hour, and it is probable that 35 miles an hour may be considered its ultimate speed. The absence of the thousand and one unforeseen emergencies that occur in the practical use of machinery of any kind, especially under such tentative conditions, has been very gratifying to those in charge of the motor. There has been no noticeable sparking or flashing at the brushes, either of conductor or commutator, which have for themselves shown a surprising and unexpected uniformity of contact and endurance. Under the heaviest work it has been subjected to no journal has ever heated, neither field nor armature has been perceptibly warmer, and everything indicates that in all respects the "Franklin" possesses a very large factor of safety.

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The Association of Edison Illuminating Companies began its ninth annual session at Kansas City on the 12th inst. with a full attendance. An important Paper by Mr. Edison on incandescent lamps was read by Mr. J. H. Vail, the secretary of the Convention. The convention was a most successful one, all the delegates reporting an increase in earnings and most gratifying prospects for the coming year. The prevailing topic, of course, was the Bate decision, and it was naturally regarded as the presage of the complete overthrow of the opposing companies. The question of joining the National Electric Light Association was discussed, and eventually negatived.

Mr. Edison had a very pleasant surprise last Monday morning. It was his forty-second birthday, and as he entered the great library in the laboratory which the day before had contained a few serviceable but unpretentious tables, some odd chairs, a few well-worn rugs and a dismantled clock, a remarkable transformation burst on his vision. Carved oak tables, handsome leather-covered chairs, each bearing the monogram "T. A. E.;" a big gas log burning brightly upon a pair of fantastic wrought-iron andirons, and a new face on the old clock, which had been connected so as to be regulated by wire direct from Washington, were among the changes. But the gem of the whole was a phonograph in steel, gold and silver, provided with the new automatic regulator for adjusting the pressure of the stylus upon the wax cylinder. It is the first "complete" phonograph ever made. Mr. Edison had been at work on the new regulator for three months, and had completed it only the Saturday previous. Mr. Edison soon evinced his recovery from the somewhat startling surprise by sending for a caterer, and ordering luncheon to be served for the 130 persons in the laboratory.

CORRESPONDENCE.

AN EXPERIMENT IN THE THEORY OF ELECTROLYSIS BY PROF. W. OSTWALD, OF LEIPZIG.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Prof. Ramsay has been good enough to send to me, as a secretary of the Committee of the British Association on Electrolysis, the following translation of a letter he has received from Prof. Ostwald. He told me of the experiment described by Ostwald some time ago, and I expressed scepticism on purely experimental, not on theoretical grounds. Perhaps scepticism is too strong a word, but at any rate I thought the assertion wanted substantiating. It is related by Ostwald as a definite experiment, but it is related without any of the concomitant circumstances which aid one so much in forming a judgment. This is the experiment referred to by Prof. Ramsay in his preliminary remarks with which the accompanying communication begins.—Yours, &c., OLIVER J. LODGE.

17th February, 1889.

[ENCLOSURE.]

The following letter of Dr. W. Ostwald requires a short introduction. In the *Zeitschrift für Phys. Chemie*, 1888, p. 270, Ostwald adduces arguments in favour of the supposition that the conductivity of electrolytes is approximately proportional to the amount of dissociation which they display in solution. I shall not here adduce these arguments, but in the introduction he gives the following "proof" that a solution of potassium chloride, for example, contains free chlorine atoms and free potassium atoms. Two glass vessels, insulated, each contain a solution of potassium chloride. They are connected together by a siphon filled with a similar solution of potassium chloride. A negatively electrified rod is placed near one of the vessels, and while it is still there the siphon is removed. The vessel nearest the rod is now positively electrified; it has received a positive charge from its neighbour vessel, and this charge has carried with it positively electrified potassium atoms, while negatively electrified chlorine atoms remain in the other vessel. These atoms are *free* in the solution. When a conducting wire is now dipped into the solution, "the potassium atoms float up to it, part with their positive charges, and then act on the water, forming potash and evolving hydrogen, which, if the charge was great enough, appears in bubbles, but which, at all events, polarises the platinum wire." Such an experiment shows that it is easy to prepare a liquid containing excess of one or other ion, and to separate the ion at the surface of an electrode by removing the electric charge of the ion.

It is unnecessary to follow the further matter of the Paper here. The view of electrolysis struck me as an unusual one, and on writing to Prof. Lodge he confirmed my opinion. The following letter from Prof. Ostwald will now be understood; it further states his views on the mechanism of electrolysis:—

LETTER FROM PROF. OSTWALD TO DR. RAMSAY.

[*Translation.*]

As regards the theory of electrolysis and the experiments described in Heft 5 of the *Zeitschrift* of Physical Chemistry, I am astonished that such simple matters can be doubted. I regard electrolysis in the following manner, without thinking for a moment that I am stating a new theory. Let E (Fig. 1) be the

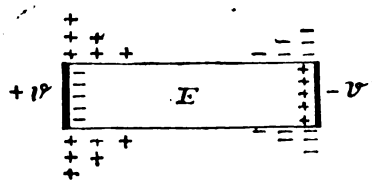

FIG 1.

electrolyte (*e.g.*, solution of potassium chloride); the electrodes are given the potential $+v$ and $-v$ in any convenient way; for example, by means of a battery. On the left side negative chlorine atoms are attracted; for I assume that a solution of potassium chloride contains many free ions of $\overset{+}{K}$ and $\overset{-}{Cl}$. The positive atoms of potassium move towards the surface, and produce the same electrostatic charge there as would be produced by the charging of a metallic conductor. Corresponding phenomena with reverse sign occur at the negative electrode. By this means an electrostatic impulse (*Triebkraft*) is given to the interior portion of the electrolyte, which urges the negative atoms towards the left, and the positive towards the right. If the potentials $+v$ and $-v$ are sufficient to force the ions to part with their electricity, they do so, and return to their usual state, and an electric current is the result; but if $+v$ or $-v$ is too small, the effect is a polarisation of the electrodes, caused by the ions adhering to them. The process of the conduction of electricity in an electrolyte is thus perfectly analogous to that in a metallic conductor, except that in the first case the electricity is in union with the ions (*an die Ionen gebunden ist*), and compels them to accompany it in its movement. Such an explanation is, of course, only possible if the existence in the electrolyte of free ions be assumed. If this be done the process, as you see, is easily grasped.

Similar conceptions explain the experiment in which a statical charge is given to a liquid. You once expressed doubt as to whether the separation of hydrogen by a statical charge could be rendered visible. I have lately made a few experiments which have shown me that it is easy. It is necessary to discharge by means of a thread of mercury of 0·01 to 0·03 millimetres diameter (as used, for example, in a Lippmann's electrometer) contained in a capillary tube, and in contact with dilute sulphuric acid. It is then possible to render visible 1 milligramme of hydrogen. To separate 1 milligramme of hydrogen requires 3×10^{11} electrostatic units; it is evident that the hydrogen from 30 units can be made visible; it forms a bubble of more than 0·01 millimetre diameter. Let me describe one of several experiments I have made in conjunction with Dr. Nernet. A (Fig. 2) is a balloon of two litres capacity, fitted with dilute sulphuric acid, and placed on an insulated stand; the balloon is covered

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with tin-foil. It is connected by means of a capillary siphon with B, a vessel also containing weak sulphuric acid, into which the capillary electrode C dips; C is connected to earth. If a positive charge be given to the outer surface of A by help of an electrical machine, the negative (SO_4) ions are attracted, and adhere to the glass walls of the balloon. The positive electricity is repelled, and along with the positive H ions passes to B until it reaches the mercury. But there the electricity alone goes further, leaving the hydrogen behind unelectrified. We have already been successful in seeing the hydrogen produced by a charge of such potential as to give a spark 0·1 to 0·2 millimetres long.

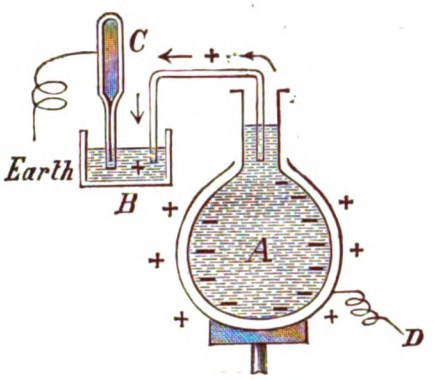

Fig. 2.

The movement of the ions under the influence of a statical charge is most easily seen in Lippmann's capillary electrometer. As you know, the indications of this instrument depend on the polarisation of the mercury meniscus. If the electrometer be connected with an insulated metallic ball the mercury meniscus makes considerable movements on the approach of an electrified body. This shows that the slightest motion of electricity in the electrolyte (here the dilute acid of the electrometer) cannot take place without a corresponding motion of the ions; it follows, as a necessary consequence, that the ions are free.

I hope that this communication, which will soon be published in full, will have removed your doubts. If you consider it desirable to send it to Prof. Lodge for publication you have my consent. I shall be glad to do anything to cause the spread of Arrhenius's happy theory.—Yours, &c., W. Ostwald.

Note by W. Ramsay.—The experiment originally recorded by Ostwald in the *Zeitschrift der Physikalischen Chemie* for April, 1888, was something like the one he describes in his letter, but lacked all precautions to render visible such a minute quantity of hydrogen as he appeared to have succeeded in seeing. I was in doubt as to the possibility of detecting such a minute charge, and also startled by Ostwald's confident assertion that the vessel B in his diagram, after A had received a charge and after the removal of the siphon, contained *free* potassium atoms, each laden with so strong a positive charge as to be unable to react on water until the charge had been removed by a wire to earth. Moreover, it appeared possible to represent the effect as one of ordinary electrolysis (whatever that may be), by supposing that the *surface* of the vessel B, and the *surface* of the contained liquid was charged positively, and that on making connection to earth a current ran from the surface *through the liquid* to the discharging wire, electrolysing the liquid during its passage. It occurs to me to ask those more conversant with the subject than I am what would happen if the vessel B were a metallic one on an insulated stand, and if it were discharged from its outer surface. The amount of current traversing the liquid would then be excessively minute. Would hydrogen be evolved? Also what would happen were the vessel B so strongly electrified that a spark could be taken from the surface of the liquid? In such a case, would the discharge not be wholly from the surface, and would the possibility of electrolysis (in the sense that electrolysis requires a current *through* the body electrolysed) not thereby be excluded?

I may add that I should not, on my own responsibility, have brought this question into prominence, although it appears to me to lie at the bottom of our conceptions of electrolysis, had I not been backed by the opinions of Profs. Fitzgerald, Carey Foster, and others, who thought it well to place it before the Electrolysis Committee for the purpose of eliciting an expression of opinion.

DISCHARGE OF A LEYDEN JAR.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Will you allow me to intimate to such of your readers as may happen to be present at the Royal Institution Friday evening, on the 8th March, that an opera glass will be serviceable for one or two of the experiments.—Yours, &c.,

Oliver J. Lodge.

21, Waverley-road, Liverpool, February 25, 1889.

HARROW LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: A report in the *Harrow Gazette* has found its way into the columns of one of the technical journals. Its form would lead a reader to suppose that it was absolutely verbatim, or, at any rate, sufficiently so to accurately represent what passed at the meeting. I find, however, on reading it over, that there are important omissions. For instance, after stating that I explained the two well-known methods of distributing electricity by alternating transformers and battery transformers, I am made to say simply that the former was the best suited for Harrow, whereas I took considerable pains to point out that although, as a rule, I had a preference for the battery transformer system, yet on account of the peculiar distribution of the Harrow lighting, in a small number of large houses distributed over a considerable area, the alternating-transformer system was at its very best as regards first cost when compared with the other; but I went on to say that if the other site which had been pointed out at the west end of the town was adopted, the balance would turn the other way.

I wish this to be clearly understood, as, since the reading of my Paper last year, and the discussion which followed thereon, there has been a disposition on the part of those who did not carefully follow that discussion to consider me as the uncompromising opposer of alternating transformers for any system of electrical distribution wherever it may be situated.

If those who are interested in the subject will turn to my Paper they will see that I then dealt with the unsuitability of the alternating-transformer system for central station lighting in densely-populated towns such as London: I acknowledged from the very first its great utility for lighting suburban districts, towns, or villages where the houses to be lighted are scattered over a considerable area, and where overhead conductors can be wholly or partially used.—Yours, &c., R. E. Crompton.

Arc Works, Chelmsford, February 26, 1889.

ELECTRIC BLEACHING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The *Paper Trade Review* in its last issue has published a letter entitled "Electrolytic Production of Hypochlorites," signed by Mr. Alexander Watt, in which it is stated that in my process for bleaching by electricity I claim the production of hypochlorite of sodium, which was patented by his brother, Charles Watt, in 1851.

Only three out of my eight specifications have been published by the Patent Office, and if Mr. Watt had waited a little longer he would have found in my first specification, which will soon be out, that I say plainly: "It must be understood that I do not claim at all the electrolysis of a chloride solution."

Now Mr. Watt, who speaks of his brother's invention, forgets, or seems to ignore, that his brother has simply copied and patented the method of electrolysis of chloride of potassium found by Gay-Lussac, Kolbe, Bouis, &c., known and experimented in France before 1851.

"En faisant passer un courant électrique à travers une solution de chlorure de potassium, M. Kolbe est parvenu à transformer le chlorure en chlorate de potasse et même en perchlorate.

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Cette expériénce répétée avec des dissolutions plus ou moines concentrées, m'a constamment fournie de l'hypochlorite de potasse.

"Gay-Lussac dans son travail sur les hypochlorites a constaté que l'hypochlorite de potasse chauffé avec du chlorure de potassium transformer ce dernier en chlorate.

"Partant de ce principe que la température d'un électrolyte s'éleve sous l'action d'un fort courant, j'ai fait passer un fort courant dans une dissolution de chlorure de potassium, la température s'est élevée, la présence de l'hypochlorite s'est manifestée et j'ai pu reconnaitre le chlorate dans les produits qui s'étaient formés."

(See *Comptes Rendus de l'Académie des Sciences*, 1849, t. XXIX., page 403, "Recherches sur l'electrolysation," par Jules Bouis.)

What right has he to stand in the way of those who, like Mr. Hermite and myself, made an industrial application of an electrolytic method, which nobody up to the present was able to make efficient, practicable, and cheap? Has not Mr. Watt's brother had the time since 1851 to make something out of his patent? He could not bleach by electricity, and the proof is that he patented in 1854 a chemical process for bleaching fibres, which, like his electrolytical process, was stillborn.

My process in no way resembles Mr. Watt's brother's process. I have no diaphragm; my electrodes are not those his brother used; I do not heat my electrolyte at 120°F., &c.—Yours, &c.,

62, Loughborough Park, London, S.W., E. ANDREOLI.
February 26, 1889.

ELECTRIC LIGHTING COMPANIES AT KENSINGTON AND WEST BROMPTON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As there is some misapprehension caused by an advertisement recently inserted in your paper as to the West Brompton Station of the House-to-House Electric Supply Company (Limited) (called by them the Kensington Station), I trust you will allow me on behalf of my company, the Kensington and Knightsbridge Electric Lighting Company (Limited), to furnish you with a statement of the works done by the respective companies in Kensington.

My company, the Kensington and Knightsbridge Electric Lighting Company (Limited), commenced in 1887 to supply electricity, under a License from the Board of Trade, in a limited area round the works situated at Kensington Court. The plant was furnished by Messrs. Crompton and Co. (Limited), who acted as the engineers and devised a system of underground mains, which gives complete satisfaction. Thereupon my Board decided to enlarge their operations, and apply for an extended area, a portion of which has since been granted. In consequence electricity is now supplied through several mains at a radius of three-quarters of a mile, and in a short time the distance will be considerably extended. There will, however, be no necessity in this district to carry the current more than two miles, as the company have a station in a central position at Knightsbridge which is now in course of completion.

From the mains already laid, shops, houses and public buildings (including the St. Mary Abbotts parish church) have been supplied with current night and day constantly with the utmost satisfaction.

As to the House-to-House Electric Supply Company (Limited), I am, after inquiring a fortnight since, in a position to state that in spite of all their protestations and advertisements, they have not to my knowledge supplied any current to houses or shops within the district of Kensington. Further, I am unable to see how they can claim to be the first company in London to supply an extended area through underground mains, inasmuch as they possess no License from the Board of Trade to break up the streets. I trust you will insert this in your next issue, as my company is suffering from the confusion which has arisen from the House-to-House Electric Supply Company (Limited) adopting the name of the Kensington station for their station at West Brompton, and making the claims above referred to.—Yours, &c., R. S. ERSKINE, Secretary.

Kensington High-street, London, Feb. 28, 1889.

THE KENSINGTON VESTRY REPORT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the leading article in your issue of the 8th inst., and desire on behalf of the Kensington and Knightsbridge Electric Lighting Company (Limited) to express their appreciation of the views expressed therein. At the same time it might be inferred that my company has been so neglectful of the interests of the industry as to act in the manner you have stated.

With regard to the unauthorised breaking up of the streets, my company have so far acted under Licenses from the Board of Trade, and as to the offers to accept a shorter period than 42 years, the term of the Provisional Order, I can only say that the proposition emanated from a rival company. I trust, Sir, that you will continue to warn the supply companies against any such stultifying action, and remain—Yours, &c.,

R. S. ERSKINE, Secretary.
The Kensington and Knightsbridge Electric Lighting Company (Limited).

COMPANIES' MEETINGS & REPORTS.

Telegraph Construction and Maintenance Company (Limited).

The twenty-fifth ordinary general meeting of the Shareholders was held at the offices of the Company, 38, Old Broad-street, on Tuesday, Mr. Philip Rawson in the chair.

Mr. WILLIAM SHUTER (Managing Director) read the notice convening the meeting and the minutes of the previous meetings, which were confirmed.

The CHAIRMAN said: I presume, gentlemen, you will take the report and accounts as read. Before commencing the proceedings, I wish to express, on behalf of our worthy Chairman, his extreme regret that he is unable to attend the meeting to-day. He is absolutely forbidden by his doctor to leave the house. He is suffering merely from a temporary ailment—a severe attack of bronchitis, I think—and that we shall soon have the benefit of his presence here again. In the meantime, he has always had a very pleasant business to perform on these annual occasions, because we have always had an account to present to you that I think must have given satisfaction. It now devolves upon me to move that the accounts and the report be accepted. In doing so I will just make a few observations, and I am very glad to think that very few observations are necessary. The report and figures are precisely in the same form which you have been accustomed to receive them. It is true that they do not enter very largely into detail; but, as you are aware, and as every business man must be aware, nobody chooses to expose the details of his business to the public, and in this instance it would be particularly undesirable that we should enter into detail. When the time comes, if it ever should come, that the meeting should demand a detailed explanation of every item, I think the time will then have arrived that you will have little confidence in your Board. Now, taking the text of the report first, you will see, without going through those figures, that we are still enabled to recommend a dividend of 20 per cent. for the year; and that during the past year the Factories at Greenwich and the Gutta-Percha Works have been very fairly employed. We have done a very considerable amount of work. A length of about 6,000 miles of telegraph wire has been insulated; that is including not only submarine wire, but wire for telegraphic purposes in this country. The company's steamers have laid cables in connection with the Dutch possessions, but I will enter into particulars of that presently. We have repaired the Brazilian submarine cable in January and August last year. We have also repaired the German Union cable once, and the Heligoland cable in March and November last year. The "Scotia" was also employed for three months in repairing the Direct United States cable. That was not a cable laid by ourselves; still, it was successfully repaired in two places and a considerable length added. A line was also laid of about 456 miles connecting the Dutch settlements of Java and Moluccas, and in August last the steamer "Macassar" left this country to connect Java with Western Australia by cable, a trifle under 1,000 miles in length, and I am glad to say we have this very morning had a telegram stating that that cable has been successfully laid, making now the third line to Australia. A little different route was chosen for that line, taking it if possible out of the district of the great volcanic disturbances of which we have heard so much of late years, and it is hoped that it will be well removed from the influence of those disturbances. A further contract, as no doubt most of you are aware, was entered into for completing and connecting the West African system with the Cape. The length of cable required for that was about 1,530 miles. The greater portion of it was manufactured this year, and a vessel will sail with it at the end of this week. That cable commences from a place called Mossamedes, a Portuguese settlement on the Western Coast of Africa, and will, when completed, be landed at Cape Town, thus completing the second line to the Cape. The fact is that Africa will then be surrounded by cable on all sides, east and west and on the Mediterranean coast. During the year, as the report already states, we have manufactured about 6,000 miles of insulated wire, including the cables and other wire for telegraphic purposes. That is about the account of our proceedings last year. The steamship

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"Kangaroo," which was chartered by the Italian Government for distilling water in the Red Sea, has been returned, and has since been sold. No vessel we ever had, perhaps, has been more useful or added more to the profits than that old ship, which was called an "old tin pot" when we bought her. It has done very useful work. The steamship "Calabria" is now on charter on very good terms, and is running from Antwerp to the River Plate for emigration purposes. She is long between decks and is very well fitted for passenger purposes. The Company's works at Greenwich and Wharf-road are in excellent working order. The Directors, as you see in the report, regret very much the loss of their colleague, the late Lord Alfred Paget, who was on this Board and rendered very earnest assistance at all times to us for the space of 18 years. Fortunately we have been in a position to replace him by Mr. William Shuter, whom you all know, and whose appointment I am sure you will all approve. Mr. William Shuter, as you are all aware, has been connected with this Company from its very commencement, and has a very firm grasp of everything connected with the Company. He knows every detail from the very beginning, and his services will be most valuable. A sum of £150,000 of Six per Cent. Debentures has been renewed at 5 per cent., and they were all, with one small exception, taken by the original holders of them. Now, gentlemen, turning to the figures. As I said before, the figures are entirely in the form in which we have always presented them to you, and I do not think they require any observations from me. I will merely say that the debts owing to the Company are perfectly good, and the sundry securities which figure here for £468,641 represent securities which are perhaps a little more valuable than those figures would indicate. I believe we have no disputed account of any sort whatever. Every account we have open with our clients has been passed as correct, and the outcome of that is a balance of £82,580. 3s. 6d., which it is now for you to distribute. I will therefore move—

"*That the report and accounts of the Directors to the 31st December, 1888, submitted to this meeting, be and the same are hereby received and adopted; and that a dividend of 3½s. per share, in addition to the 12s. per share interest or interim dividend paid on June 30th, 1888, be paid on all the shares of the Company for the year ending December 31st, 1888, and that such dividend be paid free of income-tax.*"

Mr. GEORGE W. CAMPBELL: I have much pleasure in seconding that.

The CHAIRMAN: If there is anything I have passed over, or any information I can give, I shall be very glad to give it. (After a pause.) Then, gentlemen, if nobody wishes to make any observation I will put the resolution.

The resolution was carried unanimously.

The CHAIRMAN: The next resolution that I have to present to the meeting is—

"*That Mr. George William Campbell be and is hereby re-elected a Director of this Company.*"

Admiral SIR GEORGE H. RICHARDS, K.C.B., F.R.S.: I have great pleasure in seconding that resolution.

The resolution was carried.

The CHAIRMAN: The next resolution will come from the other side of the table, I think.

Mr. GIBSON: I have pleasure in proposing the following resolution:—

"*That Mr. John Gane, F.C.A., and Mr. James Gleyg, F.C.A., be and are hereby re-elected Auditors of the Company for the year 1889, at the same remuneration as last year.*"

We are satisfied with our auditors, and I have much pleasure in proposing this resolution, and trust that some shareholder will second it.

Mr. HEWAT: I shall have much pleasure in seconding it.

The motion was adopted.

The CHAIRMAN: That, gentlemen, is all the business before us.

Mr. HEWAT: I beg to propose a vote of thanks to the Chairman and Directors for their attendance now, and for their attention to our business throughout the year, which is always satisfactory to us, but I think I need not waste your time by saying what we all believe.

General TREVOR seconded the motion, and it was carried.

The CHAIRMAN: On behalf of myself and my colleagues I beg to thank you very much for your kind expression of opinion. We shall in future endeavour to act as we have done in the past, and to promote the prosperity of the Company to the best of our ability.

The meeting then closed.

Submarine Telegraph Company (Limited).

A meeting of the proprietors in this company was held on Tuesday at the offices of the company, 2, Throgmorton-avenue, London-wall, the Hon. H. R. Brand presiding.

The SECRETARY (Mr. S. M. Clare), read the notice convening the meeting, and the minutes of the previous meeting.

The report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, in moving the adoption of the report and accounts for the last half-year, I shall not detain you by any examination of them; I think that they speak for themselves. They show a progressive business, and the main consideration I think that affects us is one of regret that we have to part with such a good business. There is one other consideration of a more satisfactory character to which I may allude. You will observe that there is a large sum of money invested in various stocks, upon which, if we take their price at the present day, there is a profit of £28,000 to £30,000. Well, now I will give you in as few words as possible all the information in our possession respecting the arrangements with the Government for the transfer of the property of this company. It might have been supposed, and reasonably supposed, that long before this date the directors would have been in a position to give the full particulars to the proprietors; and indeed if this had been merely a question of the sale or purchase of a business between independent corporations or between private individuals, there would have been very little difficulty or delay in settling the matter. But you must expect delays when international arrangements have to be made. At any rate, I can say that the Board has not been responsible for the delay that has occurred, for they offered every facility in their power to the Government, and they have acquiesced in every suggestion that the Government has made, so long as they were able to do it without sacrificing the interests committed to their charge. There is one other consideration I would ask you to bear in mind, and that is the fact that throughout the whole of these negotiations the Board has not been in the position of a free agent. Their hands, so to speak, have been tied. So soon as the Governments concerned—the English, French and the Belgian Governments—had decided to take into their own hands and to work the telegraphic system between this country and the Continent, this Company lay under sentence of death. Not only would all its rights, its authority and power cease to exist, but also—and that is the main consideration—a considerable portion of its property would have no value unless it could be transferred to those who were about to conduct the same traffic heretofore carried on by the Company. That is a consideration which has always been in the minds of the Directors, and they have been consequently hampered by the knowledge that it was a necessity to transfer their property to the Governments concerned. Well, now, it was in March last year that the Company first received a definite proposal from Her Majesty's Government. A letter was addressed to the Company from the Treasury offering certain terms of purchase. Those terms were, generally, that the Government would take over the whole of the *employés* in the Company's service with the exception of seven, to whom they offered a small and, as I think, a somewhat inadequate compensation. They then proposed to take over the whole of the property of the Company—that is to say, the cables, ship, stores, and the house in which you are now sitting—in short, the whole of our property, with the exception of the two

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The best for overhead Telephone and Telegraph Lines,
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Hard Drawn High Conductivity Copper Wire.
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PHOSPHOR BRONZE
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AND OTHER PARTS OF
ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
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WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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cables known by the name of the Deolin and Salcombe cables. They proposed that this property should be taken over at valuation in the ordinary way—that is to say, that there should be valuers on behalf of the Government, as well as on behalf of the Company, appointed, and if there were any disagreement between them, reference should be made to arbitration. Well, gentlemen, the Directors did not consider that, in some respects, the terms offered by the Government were such as they considered adequate, but in the position in which they were placed they felt that they had no option but to accept the terms thus offered. But they urged the Government to re-consider their decision as to the Deolin and Salcombe cables, and I may say that, from personal assurances which I have received at certain interviews I have had with the Financial Secretary on behalf of the Board in the Chairman's absence, I feel confident that the Government will relieve the Company of the whole difficulty with regard to these two cables. This offer of the Government was made subject to conditions, and those conditions were that the assent of the other Governments concerned should be obtained in so far as the interests of those Governments were concerned. Well, thus matters stood until a very recent date, and at a recent date we received the following information from Her Majesty's Government, namely, that they were under a Convention with the French Government either to purchase cables or to lay down cables jointly, and that the French Government and the Belgian Government had not seen their way to accept the principle of arbitration. Under these circumstances the question was, what was the course the Company should take? I would refer you again to the remarks I have made as to the position in which the Company was placed, and it was obvious that although we considered that it would have been much more to the interests of the Company that the French Government should have accepted arbitration, yet under the circumstances we were compelled to accept the position and the alternative proposals made by the French Government. That Government having refused arbitration, proposed an alternative course of action. They proposed that there should be a valuation of the cables made. I may remark here that these difficulties have reference only to the cables, not to the other property of the Company. They proposed that there should be an independent valuation of the cables belonging to the Company by the officials of the French and Belgian Governments and by the officials of the English Government, and that they should have access to the books of the Company. Having examined the books of the Company and tested the cables, they could offer the Company a price for the cables which the Company could take or leave. Now, gentlemen, the Board certainly consider that that course is a somewhat arbitrary one, and one which might lead to most inequitable results, but they feel that they had no option but to accept the proposal. It is very difficult to estimate what will be the result of this valuation, but we have received the most positive assurance from the English Government and from the French Government that they wish to deal with the Company in a spirit of equity. And for my own part I am inclined to place some confidence in this assurance, because it is impossible to believe that these great and powerful Governments should wish to take the property of this Company in any other spirit than that of equity to those who are not only shareholders in this Company, but who are citizens of either England or France, and who may well look to their respective Governments to protect their interests. That, so far, is the whole state of the case at the present moment. I have nothing to add to what I have said, except to express a hope that their arrangements will be completed and the whole thing settled by the 31st of March. If and as soon as they are completed you will be called together again to sanction them. At that time Sir Julian Goldsmid, who is now absent on business on the Continent, will attend personally. Having given all the information which I have at present in my possession, I now beg to move the adoption of the report and accounts.

The Hon. ASHLEY PONSONBY seconded the motion.

Mr. SODEN said it was a high-handed proceeding on the part of the British Government arbitrarily to revoke the Company's license and confiscate their property. If their property was to be taken from them without fair compensation the same sort of pressure might be brought to bear on other companies with far better reason than applied in the case of the Submarine Company. He would, therefore, like to ask whether any steps had been taken by the Board since last year to interest shareholders in other companies similar to the Submarine, with the view of getting their united action to protect their interests. He thought the Company had a very strong claim equitably against the Government for damages in consequence of its action in preventing the Company from getting a renewal of its concession from the French Government.

Mr. ROSTRON asked whether the negotiations had been carried on by the Board or a sub-committee of the Board?

The CHAIRMAN replied that the nogotiations were carried on between the members of the Board, the Chancellor of the Exchequer, and the Financial Secretary to the Treasury. They were not in a position to contest with the French or English Governments. It would be an act of suicidal folly if they were to take up an attitude of antagonism to the Government, and to say that they would refuse the proffered terms. It was not a revocation of the license, but the expiration of their concession that had taken place. They ceased to exist on the 31st March, and what the Government said was, "We are willing to pay you fair value for your property. You have had it all these years with great profits, and now you come to the end of your life, and we are willing to give you fair value for your property. If you do not choose to accept it you must risk getting nothing for it." The Directors felt that they would not have been acting in the interests of the shareholders of the Company if they had not taken care to give no excuse for the Government not buying the system of the Company, and thus obviating the possibility of the Government laying down cables for itself; and the shareholders might rest assured that the Board had left no stone unturned to get the best possible terms for the Company.

The motion was then put to the meeting and carried unanimously.

The CHAIRMAN next moved the declaration of a dividend at the rate of 16 per cent. per annum less income tax, payable on and after the 1st of March next.

The Hon. J. S. GATHORNE HARDY, M.P., seconded the resolution, which was unanimously agreed to.

On the motion of Mr SODEN, seconded by a SHAREHOLDER, a cordial vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN briefly acknowledged the compliment, and the proceedings terminated.

CITY NOTES, &c.

ARTHUR B. GILL AND CO.—Messrs. Gill and Co. write to us as follows:—"Sir,—You are doubtless aware of the sale of the Sun Electric Light Company, who occupy the adjoining premises to ours, viz., 5, Bombay-street, ours being No. 4. Bombay-street being an uncommon name and a short street, many people in the City and elsewhere are under the impression that we are in liquidation. You will at once see what a serious result this may have on any tenders we are in for or other work. We have already received many letters asking what has happened. As a matter of fact, we are exceedingly busy, orders for dynamos, switches, motors, &c., coming in rapidly. We are engaged on several large installations, one alone at Westminster being for 1,400 lights. May we ask you to insert a notice in your next issue to this effect, for which we shall be much indebted to you?—Yours truly, ARTHUR B. GILL AND CO."

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 22nd, 1889, amounted to £5,927.

LANCASHIRE AND CHESHIRE TELEPHONIC EXCHANGE COMPANY.—An interim dividend at the rate of 7 per cent. per annum has been declared by this company for the half year ended December last.

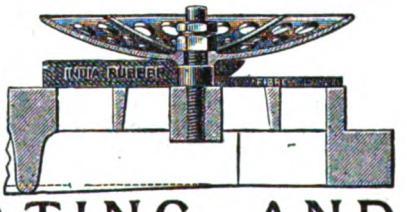
WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 22nd, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,884.

REMOVAL.—The Endolithic Ivory Company have removed from 24, Well-street, Jewin-street, to Pomona Buildings, Fore-street, E.C., adjoining Moorgate-street Station.

PERSONAL.—Mr. W. C. Mountain, having resigned the management of the Gülcher Electric Light and Power Company, informs us that he has joined Messrs. Ernest Scott and Co., of Newcastle-on-Tyne, where he has taken the direction of the electrical department.

NEW VALVE

No Rubber, Percha, or Leather.



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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Feb. 27, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Feb. 27, 1889.	
£			**TELEGRAPHS.**		£ s. d.		Highest.	Lowest.
1,770,360	Stock	7/6	Anglo-American	48 49	5 7 1	Jan., Apr., July, Oct.	...	...
2,614,820	Stock	15/0	Do. Preferred	81¼ 82½	3 18 9	,, ,,	82⅜	81½
2,614,820	Stock	5/0	Do. Deferred	16½ 17	...	February	16†	...
130,000	£10	3/0	Brazilian Submarine	13⅝ 13⅞	5 0 11	Mar., June, Oct., Dec	13 1/16	13 1/16
112,000	£7 10	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
77,000	£7 10	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14 14½	6 4 2	February and August	...	...
6,000	10	16/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3⅝ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8⅞ 9⅛	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9⅝ 10⅛	3 19 0	Jan., Apr., July, Oct.	...	...
380,000	10	2/6	Eastern	13 13¼	4 10 7	,, ,,	13 3/16	13
70,000	10	3/0	Do. 6 per Cent. Preference	15 15⅛	3 17 5	,, ,,	15 1/16	15⅛
1,300,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	107⅛	...
200,000	100	5½	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	...	...
250,000	10	2/6	Eastern Extension	13 13½	4 18 4	Jan., Apr., July, Oct.	13⅛	13
339,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	102	...
474,000	100	5%	Do. 5 per Ct. Austrin. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	102⅛	102⅛
179,177	10	1/3	Globe Telegraph and Trust	6⅞ 7⅛	5 1 9	Jan., Apr., July, Oct.	7 1/16	6⅞
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14⅛	14 3/16
150,000	10	5/0	Great Northern	15 15⅛	4 16 9	Jan., July, and April	17 1/16	15 1/16
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	41⅛	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	...	...
15,699	10	3/0	West African Telegraph	6⅝ 7⅛	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	101 104	4 16 2	March & September	103	...
30,000	10	6/0	West Coast of America	9¾ 10¼	...	January and July	10¼	9⅝
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1½ 1⅝	...	...	1 1/16	...
34,563	10	12/6*	Do. 1st Preference 6%	11 11⅓	...	April and October	11¼	11⅛
4,669	10	+	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,151	15	6/0	Western Brazilian	13¼ 13⅜	...	March & September	13 1/16	13
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	102 104	5 15 5	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	1 1/16 1 1/16	...	Yearly	¾	...
220,000	£1	2½%	Oriental (11s. paid)	½ ½	2 14 11	...	...	...
80,000	5	5/0	United	14⅞ 15	5 0 0	June and December	15⅛	14⅞
55,000	5	3/0	United River Plate	5⅝ 5⅞	...	January and July	...	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3 3⅛	...	...	3⅛	3
23,692	5	2/0	Do. (fully paid)	3¾ 4⅛	...	February & August	4⅛	4
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 3	...	...	3	2 1/16
312,000	½	5% '86	Maxim-Weston	... ...	...	February	1/16	...
			MISCELLANEOUS.					
37,350	12	12/0	Telegraph Construction and Maintenance	42 44	5 9 3	March and July	44⅛	42⅝
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	18 19	5 5 3	February & August	18⅛	18⅛

* Account arrears. † No dividend since May, 1880.

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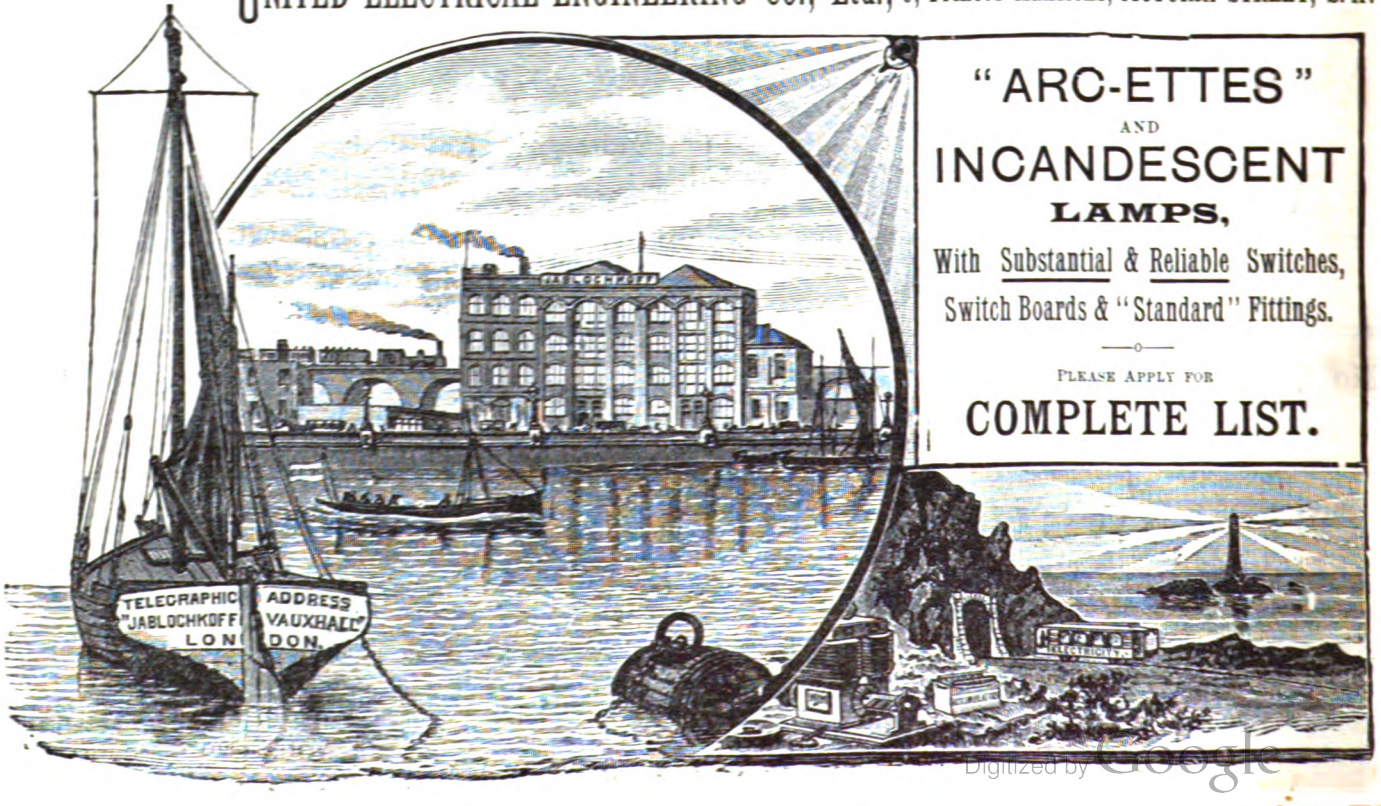

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THE ELECTRICIAN:

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NOTES.

On Monday last the Court of Appeal delivered judgment in the case of Gaulard-Gibbs *versus* Ferranti, confirming the decision of the Court below, whereby the Gaulard-Gibbs patent of 1883 was declared invalid. Matters have now, however, taken a new turn by the announcement of the recognition by the leading makers of the priority of the Jablochkoff patent of 1877. Further particulars of this will be found in a subsequent article.

Those of our readers who have the *entrée* of the Royal Institution will scarcely need to be reminded of the lecture by Dr. Oliver Lodge this (Friday) evening "On the Discharge of a Leyden Jar." Dr. Lodge intends first to run over the history of our knowledge of this subject, from the early researches of Franklin, and the long-neglected experiments of Henry (recently explained in these pages by Dr. Fleming), to the mathematical investigations of Thomson. Stress will be laid upon the generality of the problem, and Dr. Lodge will point out that *all* cases of charge and discharge are essentially of the order of the Leyden jar. The conditions of the problem will be illustrated by mechanical analogy, showing on what the rate of oscillation depends and how it can be calculated; and it will thus be made to appear that oscillations in the discharge are a necessity unless they are damped out by high resistance. The oscillations being, moreover, regular or periodic, inevitably give rise to the phenomenon of electric resonance, in strict accordance with the analogy of sound waves. Electrical analogues of the well-known experiment of causing the vibrations of one tuning fork to set another in vibration, and also of a tuning fork exciting a stretched string of suitable length, which in turn reacts upon the fork, will be described. The knowledge thus afforded by theory will be applied to the problem of reducing the speed of the electric oscillations, bringing them down gradually from some millions a second to only a few thousands, and ultimately to a few hundreds per second. As the period increases in length the noise made by the spark undergoes a striking change; from a mere crack it becomes first a shrill whistle, and ultimately a musical note whose pitch is easily ascertained. The oscillatory character of the spark will be further demonstrated by analysing it in a revolving mirror, and Dr. Lodge hopes to render the serrations of the band of light distinctly visible to every one in the theatre. Finally, the instantaneous rotation of the plane of polarisation of light will be effected by means of a Leyden jar discharge, taken round a block of "heavy" glass or a tube containing bisulphide of carbon. It will be shown that the momentary restoration of light as the current passes is oscillatory in character, and by means of the rotating mirror it will be seen that the oscillations are in unison with the spark. The image of the light which has come through the tube splits up into a broken band of light, and the bright lines are seen alternately to wax and wane when the Nicol prism analyser is rotated in either direction.

To-morrow (Saturday) afternoon Dr. Lodge will repeat some of these experiments, with others in addition, before the Physical Society, when he will, no doubt, go somewhat more deeply into theory. A new and highly-interesting experiment will be that of the production of an electro-statie field by means of varying magnetic induction. This experiment is, in some sense, the converse of that shown by Dr. Silvanus Thompson before the Royal Society last week, but it is perhaps still more completely the converse of Prof. Rowland's experiment, in which a magnetic field is produced by the rotation of an electrostatic charge. The final importance of the experiment will be greater or less according as it has or has not a bearing upon high electrical theory. On this point we believe that Dr. Lodge has not yet arrived at any very definite conclusion. It may, however, at least, be said that Maxwell's theory rendered the existence of such an effect extremely probable. We shall hope to hear the opinion of Prof. J. J. Thompson on this point. Dr. Lodge will then repeat some of the most important of the Hertz experiments, with various modifications and extensions of his own devising. It will perhaps be remembered that Hertz (see *Electrician*, Nov. 16th, 1888, p. 44) came to the conclusion that the actual velocity of electrical pulses along a pair of isolated wires was not in conformity with Maxwell's theory. We believe that Dr. Lodge will show, on the contrary, that the velocity is sensibly equal to that of light.

Prof. S. P. Thompson's Paper "On the Magnetic Action of Displacement Currents in a Dielectric," read before the Royal Society last week, was of the highest interest. According to Maxwell's well-known views of electrostatic action, the variations of electric displacement which occur during the charge or discharge of a dielectric are to be regarded as equivalent to electric currents. No direct experimental proof of this point had hitherto been forthcoming. Prof. Thompson having calculated out, on the assumption of the equivalence between displacement-currents and conduction-currents, what the effect

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would be of the charge or discharge of a condenser upon an astatic needle placed near the edge of the condenser, concluded that the effects would be too delicate to be measurable. He therefore resorted to a different method based upon the principle that, if a closed curve be drawn around the flux of electrostatic displacement, the line-integral of the magnetising force, reckoned once round this closed curve, will at any instant be a measure of the rate of change in the electric displacement through the curve. An iron annulus surrounded by a coil of fine silk-covered copper wire is embedded in a layer of paraffin wax between two glass plates, and pieces of tinfoil are affixed on the outside surfaces of the plates to serve as the coatings of a condenser. The electric displacement passes through the aperture of the iron annulus. Any changes in that displacement set up magnetic forces acting round the iron annulus, which thereby is subjected to a varying magnetisation. The annulus in turn sets up induction currents in the copper wire that surrounds it, these induction currents being received and rendered audible in an ordinary telephone receiver. The condenser is connected to a Ruhmkorff coil, which rapidly charges and discharges it. The sounds heard in the telephone receiver are taken to establish the reality of the magnetic action of the variations in the electric displacement. The author points out that this device, which may be regarded as a new kind of proof plane for exploring varying electrostatic fields, is probably capable of other useful applications, such as the investigation of specific inductive capacities. It will, however, be evident that the results require to be interpreted with the utmost care to avoid the interference of extraneous actions. But in any case the immense ingenuity of the experiment will be patent to all, and Prof. THOMPSON's further communications upon the subject will be looked forward to with great interest.

THE important Paper of Prof. FORBES on "Some Electric Lighting Central Stations in Europe and their Lessons," read before the Institution of Electrical Engineers on February 28th, was divided into distinct portions; the first part included a detailed description of the central stations of Berlin, Milan, and Rome, and the second part was more particularly devoted to the lessons which English engineers may derive from a study of the Continental stations. The second part of the Paper being quite complete in itself, we print it first in order to give proper time for the preparation of illustrations for the former part. Meanwhile we commend Prof. FORBES's "Lessons" to the careful consideration of every engineer engaged in central station work.

THERE is much in this Paper of Prof. FORBES upon which we should like to comment, but in the present issue space will not permit us to do more than refer to a single point. We observe that Prof. FORBES lays stress upon the calculation of mains and feeders in accordance with the law of THOMSON. We venture, however, to doubt whether the formula in question really admits of practical or useful application except in the case of constant-current circuits. It is not the truth of the law itself that we call in question, but the possibility of discovering the data to which it is to be applied. It is true that Prof. FORBES himself has greatly facilitated its application by means of the valuable tables which are given in his "Cantor Lectures" of 1885. But not only is the question grievously complicated by the fact, insisted on by Mr. CROMPTON, that the cost of copper bears a smaller ratio to the total cost of laying mains than was at first supposed, but still more fatal is the difficulty of ascertaining what is the value of the square root of the mean square of the current taken over a whole year. Even for a station already in operation the determination of this quantity would be sufficiently troublesome, but to do so on paper before the station is constructed would be simply impossible. In practice we know that it is customary to calculate out the mains on the basis of the permissible fall of potential under full load at the extremity of the circuit, and since we thus obtain the minimum permissible value, it seems doubtful whether it is worth while to hazard a further capital expenditure upon the result of a hypothetical application of the law in question. We do not suppose that Sir WILLIAM THOMSON would himself recommend the use of the formula where the data are so little ascertainable.

AT the Society of Arts on Wednesday evening Prof. S. P. THOMPSON delivered a most interesting and practical address on Arc Lamps. When Prof. THOMPSON undertakes to deal with a question of this kind we have learnt to expect from him a systematic exposition alike of the history, the practice, and the theory of his subject; it is therefore sufficient to say that Prof. THOMPSON on Arc Lamps exhibited the same qualities which characterise his now classical Papers on Mercury Pumps, on Influence Machines, on the Reiss Telephone, and on Dynamo Electrical Machinery. Next week we hope to reprint the address from the *Journal* of the Society of Arts, but it is much to be wished that he could be induced to expand the lecture into the form of a treatise.

THE renewed attempt to introduce into the telegraphic world a Morse code with its dots and dashes perpendicular to the paper instead of horizontal will be noticed with interest by those of our readers who remember Mr. HERRING's energetic endeavours to impress this system on Mr. SCUDAMORE nearly twenty years ago. Messrs. SIEMENS' ingenious method, which we describe and illustrate in another column, differs materially from Mr. HERRING's; but the object is the same; and in addition to the difficulties he had to encounter at that time there is now an additional one in the general adoption of Morse "sounders" to the exclusion of ink-writers altogether, except for fast speed working. If Messrs. SIEMENS' mechanical device can be trusted for Wheatstone "receivers," something possibly may be said for its adoption; but we are not prepared to endorse the opinion that the operators would prefer this kind of "printing." Mr. HERRING said the same thing, but we rather fancy nobody else did.

ALTHOUGH opinions differ as to the possibility of the Copper Syndicate tiding over without absolute disaster the crisis now impending, there is a general agreement that prices will

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shortly go down, sellers for delivery of copper at three months accepting terms far below present quotations. The steady refusal to buy at an abnormal figure has at length brought the Société to its senses, if not yet exactly to its knees, the total deliveries during the past twelve months amounting only to 59,052 tons, while the supplies, it is said, have exceeded 124,000 tons.

SOME reassuring statements were given in Parliament by the POSTMASTER-GENERAL on Monday last with regard to the acquisition of the Anglo-French and Belgian cables. Little doubt now remains that the whole of the lines connecting this country with the Continent will be working under the control of the several Governments at the beginning of next month. More than this, there is good reason to believe that reasonable counsels have at length prevailed with the French Government in respect to the cables and plant of the Submarine Telegraph Company, and that their property will be purchased, if not at what the company consider a fair price, at a valuation something substantially above that of old stores.

SOME few weeks ago a paragraph appeared in the *Financial News* to the effect that electric traction was only to be used upon one portion of the City and Southwark Subway, and that cable haulage would be employed between the Monument and the Elephant and Castle. This information was so much at variance with facts within our own knowledge that we passed it by without remark. On Wednesday, however, our contemporary repeated the statement in categorical form, and descanted upon the folly of the proceeding in no measured terms, as may be seen from the following extract:—

"No sane body of men would dream of increasing the capital expenditure of such an undertaking by installing two different systems of haulage in a subway about four miles long. The change of the power used is almost as silly as a break of gauge would be. Every vice of mismanagement is embodied in this mischievous policy, and the directors owe not only an explanation to the shareholders, but also their resignation."

Although this language is a little rougher than that which we are ourselves accustomed to employ, yet it would be scarcely too strong if the facts were precisely as our contemporary supposes them to be. We have reason, however, to believe that the case is not quite so bad as this. It seems to be true enough that a cable plant is to be put in, but this will not be allowed to interfere with the contract with Messrs. MATHER and PLATT, which involves the actual working of the whole line by electricity. The cable is, in fact, to be put in as a stand-by. But we are entirely of opinion that this will prove to be a wholly superfluous precaution.

WHILE reading lately an interesting work on electricity, written a hundred years ago by one GEORGE ADAMS, "Instrument maker to His Majesty," entitled "An Essay on Electricity, explaining the Principles of that Useful Science, and describing the Instruments contrived either to Illustrate the Theory or to render the Practice Entertaining," our attention was arrested at an early stage by frequent allusions to Directors, and in particular to the "bottle director." Since those days electricity has suffered much at the hands of directors, but the bottle director is now, we believe, an extinct variety. Judging, however, from the rigorous treatment herein prescribed for him he must have been a fearsome creature when in his prime. One means of dealing with him is as follows:—"Connect a director by means of a wire with the ball of a Leyden jar, charge the jar, and then apply the point of the conductor." We then learn that "if a wire is conveyed from the bottom of this to the top of another director, the bottle director will be discharged." It would be a fine thing for the profession if directors were as easily discharged nowadays.

Burton-on-Trent.—The National Telephone Company's new exchange at Burton was formally opened last week by the Mayor.

St. Olave's Board of Works.—At a special meeting of this Board last week it was decided to take no action with regard to the electric lighting of the district.

Melbourne Exhibition.—Messrs. Gent and Co., of Leicester, have received a first-class award at the Melbourne Exhibition for their exhibit of electrical apparatus.

The Thomson Electric Welding Company.—This company has issued a neatly got up pamphlet describing the Thomson process, and enumerating its many advantages.

"Western Electrician."—Our enterprising contemporary the *Western Electrician* brought out a daily edition during the recent meeting of the National Electric Light Association at Chicago.

Accident to Mr. Edison.—We regret to learn that Mr. T. A. Edison has been badly injured in the eyes by chemicals during an experiment. By a later telegram it is stated that no permanent injury is likely to arise.

An Insulation Knife.—The *Elektrotechnischer Anzeiger* of Berlin calls upon makers of tools to bring out a special instrument for stripping insulation off wires, to replace the present rough and ready method of scraping with a knife.

Lisbon-Oporto Telephone.—A new telephone line has recently been completed between these two towns, and will be shortly opened to the public. The charge for five minutes' conversation will probably be fixed at 200 reis (about 11d.).

Electric Wire Casings.—Mr. Samuel Elliott, of Newbury, has just issued a new illustrated catalogue of his well-known electric wire casings. Drawings of over one hundred varieties of casing are given, many of which are of very tasteful design.

Sale of Postal Telegraph Stores.—Messrs. Horncastle and Pember announce the annual sale of postal telegraph stores, by order of the Postmaster-General, on Wednesday, March 13th, at the Commercial Sale Rooms, Mincing-lane, London, E.C.

Telegraphic Money Orders.—In reply to a question by Mr. Henniker Heaton on Wednesday evening Mr. Raikes said he hoped soon to be able to announce the date when telegraphic money orders would be introduced by way of experiment.

Gas and Electricity.—It is stated "upon the authority of a Parliamentary return" that the total capital now invested in gas lighting in this country amounts to £74,289,595, of which sum no less than £7,216,897 has been invested within the last seven years.

Engineers' Society of Western Pennsylvania.—The secretary of this society writes us to the effect that the library rooms are open daily, and engineers from any part of the country are invited to call and make themselves known to the secretary, Col. S. M. Wickersham.

Proposed Electric Railway in India.—The *Indian Engineer* says that Colonel Thomason, R.E., is busy surveying the country between Naini Tal and the plains, at his own cost, with a view to the construction of an electric railway, for which he considers the available water-power furnished by the lake, now running to waste, sufficient and to spare.

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Milan.—A paragraph appeared last week in our contemporary *La Lumière Electrique* to the effect that a serious breakdown had occurred in the lighting of Milan. We have, however, received a letter from a correspondent on the spot, who states that this rumour is absolutely without foundation, and that the entire plant is continuing to work with perfect success.

Okehampton.—The directors of the Okehampton Gas Company have decided to apply to the Town Council for permission to lay cables in the various streets in the town for the purpose of supplying the electric light. The directors have thought this step advisable in consequence of the successful installation of the electric light in the town by a local firm (Messrs. Geen and Co.).

The Lighting of Mexico City.—Mail advices just to hand, dated Mexico, February 15, state that the city is at present illuminated by 300 arc electric lights of a combined lighting power of 600,000 candles; 114 turpentine and naphtha lights, of an illuminating power of 11,140 candles; 123 oil lamps, of an illuminating power of 783 candles; and 501 gas lamps, of a lighting power of 4,008 candles. The monthly cost of maintaining these lights is stated to be $13,449.

St. George's (Hanover-square) Vestry.—At a meeting of this Vestry last week the Electric Lighting Committee submitted a report recommending the Vestry to refuse altogether the application for a Provisional Order made on behalf of the Chelsea Electric Supply Company. The committee had adjourned the consideration of applications by the London Electric Supply Corporation, the Metropolitan Electric Supply Company, and the Westminster Electric Supply Company, all of which would be reported upon at a future meeting.

Lighting Buoys by Electricity.—The South Wales *Daily News* suggests that the unilluminated buoy off Lavernock Point should be lighted by electricity like the buoys in Gedney's Channel, New York Harbour. "On a clear day," this journal remarks, "there is absolutely no necessity for it, and at night and in thick weather it cannot be seen. Moreover, it is a source of danger, as considerable care has to be exercised to prevent coming into collision with it. If it is to be kept in its present position and turned to some account, there is no question that it should bear a light."

Telegraphs in Mexico.—Mexican advices state that the telegraphic system of Mexico is being rapidly extended throughout the country, and now all the cities and large towns and nearly all the important villages are in direct telegraphic communication with the capital. One of the leading papers says that the ordinary rates over the Government wires are quite moderate, and doubtless do much to encourage the people to make liberal use of the telegraph. It is argued, however, that the rate for press messages is too dear, and a reduction is asked for from 1 cent. per word, the present rate, to ¼ of a cent. per word.

Bremen.—The Electric Lighting Committee of the Bremen Municipality has decided by six votes to one to recommend the Council to refuse the offer of Messrs. Siemens and Halske to undertake the lighting of the town. The committee point out in their report that the result of such a contract would be a high tariff; on the other hand, the towns which have undertaken the work themselves have already been able to materially reduce their original charges. Messrs. Siemens and Halske at present fix the expenses of working 12,000 lamps at 2·46 centimes per lamp hour, and 22,000 lamps at 1·85 centime per lamp hour.

Copper.—The *Daily News* says:—"The deliveries of copper in England and France last month were only 1,397 tons, being the lowest remembered, and barely a fifth of the average monthly deliveries of the past three years. Of late consumers have been holding off the market with the greatest determination, prices for delivery three months ahead having been much below the spot quotations. What the French syndicate are gaining by upholding these prices it is difficult to see. Meanwhile the visible supply is 118,140 tons, an increase of 8,612 tons for the month and of 65,547 tons for the past twelve months. If the price were reduced to £65, and kept steady, they might—with aid on this side—escape disaster yet."

Submarine Mining.—Major Grant Ogilvie recently delivered a lecture to the members of the East of Scotland Tactical Society on "Submarine Mining." Major Ogilvie pointed out that the old mechanical mines were as much in the way of friend as of foe, and were difficult to remove after hostile operations were over. Among the many possibilities which an electrical arrangement introduced he enumerated a few. These were (1) the mines might be laid out and remain quite harmless so long as the firing current was not put on; (2) the mine might at any time be fired from the shore; (3) the mine might be fitted with a firing apparatus, so that the bumping of the mine by a vessel would complete the circuit and fire the mine; (4) the arrangement of the firing apparatus might be altered so that bumping would merely indicate on shore that a certain mine had been struck, and thus leave it to the discretion of the officer in charge whether the mine should be fired or not. In conclusion, Major Ogilvie remarked that the utility of mines as a means of defence must not be measured merely by the actual damage they inflicted, but their moral effect must be taken into account as well.

Taff Vale Railway and the Electric Light.—As we mentioned in our issue of December 14th, the Taff Vale Railway Company have decided to light two trains on the Penarth section by electricity. This is intended as an experiment only, but should it turn out successfully the whole of the trains on the system will be similarly lighted. Some details of the method to be employed are now to hand, and it will be seen that it is substantially the same as that which has been worked so successfully on the Brighton and South Coast Railway. The dynamo, which is a Brush machine specially wound so as to maintain a constant difference of potential at the terminals while the speed varies between certain limits, is run off the axle of the guard's van. The lamps (12 candle-power Edison-Swan) are run direct off the machine whenever the train is going at its normal speed, but when the speed is reduced the lamps are automatically switched on to a battery of accumulators. During the time the train is running the dynamo is charging the accumulators as well as furnishing current to the lamps. The cables are run along the roofs of the carriages, being connected at the end of each by means of a special coupling.

Gas Mains as Electrical Conduits.—Mr. P. H. Wilkinson, of Harrogate, writes to the *Journal of Gas Lighting*, as follows:—"I notice that, in an extract from the *Electrical World*, a claim for having in 'the first instance' applied telephonic wire in gas-mains is attributed to New York for work done about four years ago. Upwards of five years since—viz., in August, 1883—I laid down a number of 16 B.W.G. copper wire, gutta-percha coated to No. 4, and protected with prepared tape covering, in a live gas-main upwards of a mile long from the office to the works, with branches therefrom to my residence. The wire was laid on the bottom of the gas-main without any further insulation. I have testing-boxes, easily accessible, every 250 yards, and any portion can be taken out or renewed if required. . . About 400 yards of a 2in. main carries two wires, and three or four main valves are passed *en route*. The insulation appears as good as when it was put down, and no repairs whatsoever have been required. The gas mains carrying the wire run for about 500 yards within two or three feet of a main line of underground telegraphic wires, some of which have been renewed at least once during this period. A previous wire of similar description, carefully laid in pitched wooden troughs and in good soil, was continually under repair, and was frequently unavailable when particularly required; and in a few years it was left in the ground as useless."

The Thomson-Houston Electric Railway System.—The Thomson-Houston Electric Company have recently issued a well illustrated and readable pamphlet of some 30 or 40 pages, describing the various lines at present in operation under their patents, and announcing that they have purchased all the patents, privileges and licenses of the Van Depoele Company, of Chicago. The greater portion of the pamphlet is taken up by testimonials from users of the Van Depoele and Thomson-

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Houston systems. Some few pages at the end are devoted to combating possible objections to an overhead wire system of electric traction, and to demonstrating the unsatisfactory nature of the battery system. "There are now in the United States alone more than thirty electric railways operated entirely by the direct method; there is not a single railway operated entirely by storage batteries. Experimental storage battery cars are, however, run from time to time on various roads, and many railway officials are induced to ignore the practical success of the direct system, and to wait the development of an ideal system, which so far refuses to be developed." We notice on page 39 that the trolley making a flexible upward contact, which forms so marked a feature of the Sprague line at Richmond, is said to be covered by a patent granted to Mr. Van Depoele.

Greenwich Board of Works.—The Greenwich District Board of Works met specially on Wednesday last week to consider an application made by the London Electric Supply Corporation for a Provisional Order for the supply of electricity in the district. The Clerk thought that the company would not be prejudiced by delay, and in his opinion it was necessary that the committee should have the services of an electrician. He suggested that a meeting should be held a fortnight hence, and that an electrician should be consulted. The Clerk's advice was adopted. The Clerk then reported that the Electric Light Supply Corporation had excavated roads in Deptford, and commenced to lay down mains, but he had stopped them, as they were blocking the thoroughfares. The Corporation ought to have done the work at night and in the way prescribed by the Board's officers, but instead of so doing they had put the matter in the hands of two gentlemen who seemed to have had no experience whatever in digging trenches and laying pipes. They employed 100 men out of the streets, and the work was done in a most unworkmanlike manner. The Manager and Secretary of the Corporation had expressed their regret that any irregularity had been committed, and had given orders for nothing further to be done at present. It was obvious that in putting down these pipes the Corporation were attempting to steal a march on the public and to get as many of their mains laid as possible. It was then agreed that the Clerk should give notice to the Corporation to undo all they had done.

Nottingham.—At the meeting of the Nottingham Town Council last week the following letter was read from Messrs. Maples and McCraith:—"Dear Sir: We are instructed by the Nottingham Electric Light and Power Company (Limited), a company which has just been formed with a registered capital of £100,000, to ask for the consent of the Town Council to the putting down of underground wires in the town of Nottingham for the purpose of the supply of electric light and power. The area proposed, speaking generally, is the Nottingham Park and the lace market, with some streets adjoining thereto. What is suggested is that the main streets should be taken in that area, such streets to be settled between the company and the Corporation. The company will be prepared to incur a very considerable expenditure at once, and are desirous of proceeding with the matter as quickly as possible; for this reason, therefore, we propose that the Corporation should proceed as has been done by the Metropolitan district, by the Vestries (acting under the advice of their Parliamentary agents), namely, enter into an agreement with the company to in 'so far as the Corporation powers extend, give to the new company the privileges and concessions which a Provisional Order would give when obtained.' The company would then proceed with the works (thereby supplying employment to a considerable number of persons in the town), give notice of the Provisional Order, and in all probability obtain same by the middle of next year. The company would be quite willing to insert in the agreement with the Corporation the same regulations as to public safety and other points which would be inserted by the Board of Trade in the Provisional Order. As the company understand that the lighting of the Castle Museum with the electric light would for many reasons be considered a public benefit they would be prepared to undertake this on very favourable terms. Our clients, the company, as they are asking for a concession of a particular area, will be prepared to submit to compulsory powers in that area. As to the streets, of course, this is a matter which will have to be arranged entirely subject to the Corporation views, although we may say that the street disturbance in laying down wires is extremely slight. The company will throughout the matter be desirous of acting in thorough unison with the Town Council and its advisers.—We are, dear sir, yours faithfully, MAPLES and McCRAITH." The Mayor said the application made by the Electric Light Company was of so important a character that he thought it advisable to move for the appointment of a special electric lighting committee to consider the matter. This was agreed to, and a committee was appointed accordingly.

Cheltenham.—The following is an abstract of the report of the Electric Lighting Committee of the Cheltenham Town Council, which will be considered at a meeting of the Town Council on Monday next. In reporting the committee first called attention to the position in which the question of electric lighting in Cheltenham at presents stands. Several interim reports have already been sent in by the committee to the effect that it was desirable to try the experiment of lighting a portion of the town with the electric light, and further, that it was desirable that the lighting of the streets should be carried out by the Corporation. These resolutions were accepted unanimously by the Town Council, who directed the committee to inquire into the question of cost. The report then goes on to say, that "With a view to make their estimate of cost, though approximate only, one that may be relied on as sufficient, the committee have placed themselves in communication with two of the largest electric lighting companies in the world, and have obtained from them covering estimates, that is to say, estimates within which they would themselves contract to do the work. From the inquiries made by the committee and information supplied to them, they have been strengthened in the conclusion they had come to that the cost of the public lighting would be very materially reduced by combining it with the supply of the light to private consumers, as it is well known that the electric light can be produced at a proportionately lower cost when the size of the installation is increased, and they have, therefore, included in their estimate provision for such combined supply. The committee have invited estimates on the basis of the supply of 60 1,200 candle-power arc lamps, and of from 2,000 16 candle-power incandescent lamps. From the particulars and information afforded to your committee they have come to the following conclusions:—That motive power, generating machinery, circuit, lamps, and other plant sufficient for 60 arc lamps of 1,200 candle-power each, and 2,300 incandescent lamps of 16 candle-power each, including £1,800 estimated cost of site and buildings, can be erected for £11,900. This estimate is based on the circuit being partly underground and partly overhead. On the assumption that the whole of the arc lights will be alight on an average nine hours per night, and that the incandescent circuit has pressure on for 18 out of 24 hours, the incandescent lamps being supplied by meter, and alight on an average 1,500 hours each per annum, the annual cost of the production of this light, including repairs, maintenance, depreciation, and interest and repayment of capital, will be from £3,300 to £3,700 per annum. Assuming that 2,000 16 candle-power incandescent lamps yield an income of about ½d. per lamp per hour, and 20 arc lamps are let out at £15 per annum each, your committee estimate that the cost of the 40 public arc lamps would be under £250 per annum. As will be seen, the number of lamps in the foregoing calculation is below the number which the plant is designed to supply, and as the demand for light increases the income will increase accordingly, which will allow of a proportionate extension of the public lighting at no greater cost. Your committee estimate that 40 arc lights would render unnecessary 180 of the existing gas lamps which at the present reduced price per lamp would cost about £450 per annum. A saving of £200 per annum would, therefore, be effected in the public lighting, while the power of the light would be many times greater. Your committee having now given, as directed, an approximate estimate of the cost of the electric lighting proposed, ask to be allowed to proceed with the matter and procure tenders to be submitted to the Council."

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 479.)

By the aid of the ideas which were discussed in the last section we are enabled to arrive at a mechanical conception which helps us to connect together observed facts, and which, even if not a real representation of what is taking place, is at least a working model which may not be an altogether incorrect imagery of the actions taking place when an electric current is started in a wire.

An electric current on this hypothesis is a flow or progression of the electric particles which are free to move forward in a conductor, and which only can move steadily forward, owing to their incompressibility, when the circuit in which they flow is a complete circuit. Suppose a thin conductor bent into the form of a very large circle, and that an electromotive force urges a procession of electric particles round it. As these particles go forward they cause the electric *cells* next them to rotate, and the motion of this line of cells embracing the line of current will be just like that which would take place if a bracelet of spherical beads strung on an elastic thread were rolled along a round rod which it closely embraces. Each bead would turn over and over, rolling on the rod, and the motion of the whole bracelet would be like that of a tightly-fitting india-rubber umbrella ring pushed along a round ruler. The progression of the electric particles would start circular vortex rings revolving round the line of motion. This corresponds to the fact that a linear current creates a magnetic field composed of circular embracing lines of forces. The first or adjacent line of vortices would, by the intervention of the idle wheels, set in rotation another set of cells lying on a concentric line, and cause them to rotate in the same manner as the first ones. Also, it would cause a backward displacement of the intermediate idle wheels, if we consider that only the central line of electric particles are conducting matter, and that the next and all succeeding rows are in a dielectric. The starting of the progressive movement of the line of electric particles in the conductor will result in an elastic displacement in the *opposite* direction of all surrounding electric particles in the dielectric along lines parallel to the line of current; and also in setting up a system of molecular vortices composed of revolving cells, the axes of these vortices being coaxial circles described round the line of flow, the rotations and displacements being propagated out laterally from the line of current. In consequence of the fact that the revolving cells are supposed to possess inertia or mass, and that all the mechanism is supposed to be rigidly connected together, a steady force applied to set the central line of electric particles in motion will not be able to produce in them the full velocity until time has elapsed sufficient to allow the inertia of the connected mechanism to be overcome. We are thus able mechanically to imitate the phenomena of *self-induction* of the circuit and the gradual rise of current strength in an inductive circuit under the operation of a steady impressed electromotive force, and to deduce it as a consequence of the fundamental hypothesis.

Our theory, then, points out that a current should rise gradually in strength, and also that the embracing lines of magnetic force must be considered to come into existence successively as the rotation is taken up in ever-widening circles by the molecular vortices successively receiving motion of rotation. Also, on withdrawing the impressed electromotive force the inertia of the mechanism tends to make it run on for a little, and the electric particles, which by their motion started the vortices, are now themselves urged forward for a little in the same direction, and this constitutes the *extra current* at "break." Let us next endeavour to see what ought to happen on the supposition that there are two conducting circuits in the field, both forming closed circuits, and to one of which an impressed electromotive can be applied. Let V_1, V_2, V_3, &c. (Fig. 27), represent the sectional view of a series of vortex lines of electric cells, and let I_1, I_2, I_3, &c., be the idle wheels or electric particles. Let the row of electric particles I_1 be supposed to be lying inside a conducting circuit, A, represented by the dotted lines, and by our fundamental supposition, the particles I_1 are quite free to move along the conductor, and to rotate on their axes. Let there be another conductor, B, placed parallel to A, and let I_5 be the electric particles in it. The space C between is supposed to be occupied by a dielectric, and in it the electric particles can only be displaced elastically from a fixed position. We may regard these idle wheels I_2 I_3 I_4 as tethered by springs to one spot. Such being the mechanism, imagine that the row of particles I_1 is urged forward in a downward direction. As the row of particles pass between the cells V_1 V_2 they will set them in rotation in opposite directions. Owing to the inertia of the vortices the first effect of the rotation of V_2 will be to cause I_2 to roll over V_3 and be displaced in an upward direction; its displacement is resisted by the elastic force of the spring. The rotation of I_2, however, sets V_3 in rotation, and after a short interval V_3 is rotating at the same speed and in the same direction as V_2. I_2 then ceases to be displaced, because the action of V_2 on I_2, and the reaction of V_3 on I_2, simply amount to a *couple* or *twist* on I_2. The same sort of action results in a gradual handing on of the rotation from vortex to vortex, and a propagation of displacement from one idle wheel to the other. When the motion reaches the conductor B, the first result is to cause a displacement of the electric particles upwards, the rotation of V_5 not being instantly acquired by V_6. This amounts to a current in the upward or opposite direction. As soon, however, as the vortex V_6 has accepted the full speed of rotation, then the forces on the electric particles I_5 amount only to *twists*, and not to forces of displacement; hence, the particles I_5 cease to

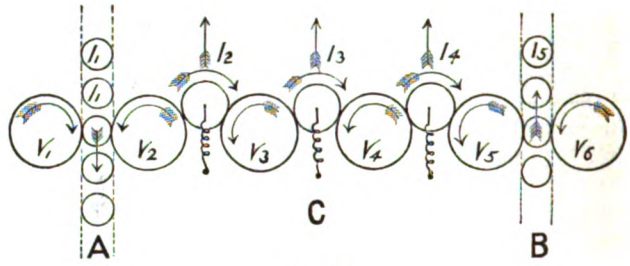

FIG. 27.

experience any force impelling them forward, and come to rest in virtue of the fact that the conductor offers a resistance to their motion. They fritter down their energy of motion into heat, and come to rest. Hence, the induction current in the conductor after a short flow ceases, and the vortex spin becomes equal in the vortices on either side of it. Suppose now that the impressed force in the circuit A is withdrawn, the electric particles in the A circuit are driven forward for a short time by the energy stored up in the adjacent vortices; these last, however, give up one by one their energy to the circuit A, where it is dissipated as heat. This surrender of velocity is propagated outwards until at the surface of the circuit B the state of things finally is, that when the vortex V_5 has come nearly to rest, the motion of V_6 still continues. The energy of V_6 and of vortices beyond expends itself in moving forward. The electric particles in circuit B, in the same direction as that in which the current in A was travelling originally—in other words, part of the energy of the field—is spent in making a transitory current in B as well as in A in the same direction. It follows, therefore, that there is a less induction current in A at breaking circuit when a circuit B is present than if B were not there—that is to say, the presence of a closed secondary circuit, B, diminishes the self-induction of the primary circuit, as is known to be the case. We see, therefore, that the theory is so far in accordance with observed facts.

(To be continued.)

A Complete History of Lightning Conductors.—The Société Scientifique et Littéraire des Instituteurs de France proposes as one of the subjects for competition this year a complete history of lightning conductors.

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SIEMENS' RECORDING APPARATUS FOR COMPACT MORSE WRITING-PATENT.

The alphabet formed by the combination of two elementary signs, the "dot" and the "dash," which is used in Morse telegraph instruments of the recording type, is almost universally written in a single longitudinal line on the paper strip.

This method of writing, however, possesses the great disadvantage that the diameter of the writing disc cannot be made very small, as it would not then be certain to dip into the ink contained in the trough. A disc of comparatively large diameter, although clean in its working, is unsuitable for producing a short and sharp sign on the paper strip, particularly when the strip is moving slowly, as the tangential contact between the writing disc and the paper produces an unnecessarily long sign with a large disc, and hence the tendency to "tailing" is increased. It is for these reasons that the "dots" of the Morse alphabet can in general practice only be produced as short dashes, so that, in order to prevent misapprehension, the "dashes" require to be made longer than would be necessary if distinct dots could be produced. The writing is thus spread over far more paper than is desirable, causing not only a waste of paper but making the reading more difficult.

Various suggestions have from time to time been made with the object of remedying this defect, but owing either to complication in the methods of transmission or of reception, none of these proposals have been adopted to any considerable extent.

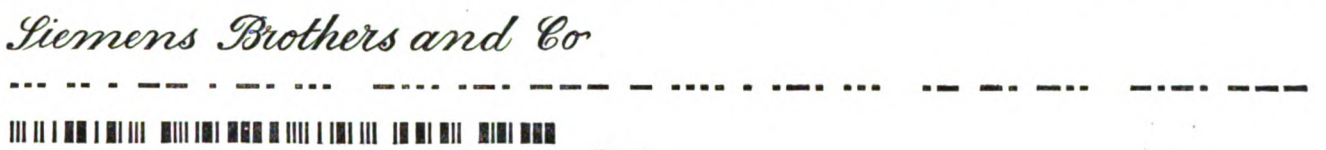

FIG 1.

The "Compact Writing" has been designed to meet the demand for improvements in the old system of Morse writing. Its elementary signs consist of lines at right angles to the edge of the paper strip and of equal width, but of different length (measured in the direction in which the paper travels), a short or thin line representing a "dot," and a longer or thicker line a "dash."

Fig. 1 illustrates the old and new system of writing, and shows the relative difference in space occupied by them. The length of paper used for the compact writing is about half that used for the old writing, while a more readable message is produced. The

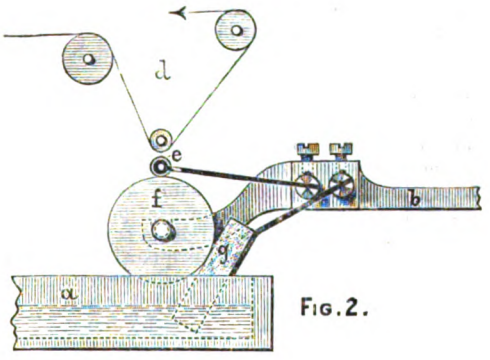

FIG. 2.

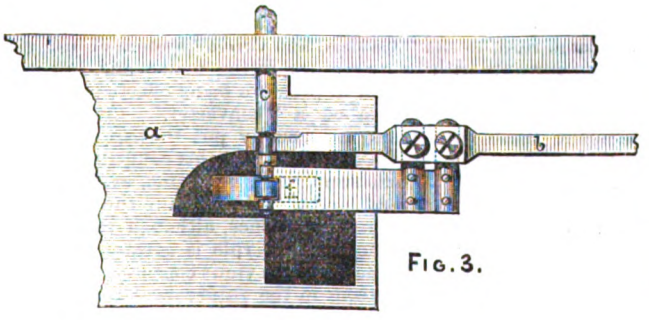

FIG. 3.

amount of paper strip to be stored away for possible future reference thus becomes considerably less—an administrative advantage not to be underrated when the present enormous increase in telegraphic communication is taken into account.

The inking arrangement by which these compact signs are produced consists, as shown in Figs. 2 and 3, of a marking roller *e*, of small diameter and of a width equal to that of the marks to be produced, mounted with its axis at right angles to the edge of the paper strip and rotated by its frictional contact with the inking disc *f*. This inking disc is carried on a spindle, *c*, resting in a bearing on the end of the armature lever *b*, and is geared with the clockwork of the instrument by which it is revolved. It is of slightly greater width than the marking roller, and has a finely grooved periphery for more effectually taking up the ink.

a is an ordinary ink trough, and *g* is a pad of felt which dips into the ink and presses against the inking disc.

The marking roller *e* and the inking pad *g* are both attached to the armature lever by flexible arms, and the amount of their pressure upon the inking disc is regulated by small set-screws.

d is the ordinary train of wheels over which the paper passes.

When the instrument is at work the end of the armature lever carrying the marking roller, inking disc, and inking pad is moved upwards by the action of the electro-magnet, the marking roller being thereby pressed against the paper, making a short or long mark, according to the duration of contact. The inking disc is rotated by the clockwork, and, being supplied with ink from the pad, carries it to the marking roller, which it at the same time causes to revolve. In this manner the marking roller receives a very even, though ample, supply of ink, and a freshly-inked surface is constantly presented to the paper, by which means, combined with the very small diameter of the roller, short, sharp, and distinct marks are produced.

The invention claim that experience has shown that any disinclination that may be felt by telegraph operators to change the method of writing the Morse code is soon removed by the conviction that the new system offers considerable advantages to themselves, and that no difficulty whatever is experienced by the change from the old system to the new.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

"Lessons to be Learned from Foreign Central Station Lighting."*

BY PROF. G. FORBES, F.R.S.

I propose to deal with some of the problems of central station lighting which we in London have now to face. I judge by the practices I see common in this country that I shall, as to my opinions on many points, be at variance with some of my brother engineers, because in the work which has hitherto been done I see that the experience of foreign countries has very often been neglected, and the rule seems to be to neglect the opportunity of utilising the experience gained at great expense of time and money in foreign countries, while our progress was being retarded by the Electric Lighting Act. But my conclusions have been arrived at after a most careful consideration of the successful work which has been done in Europe and America, and I am ready to condemn foreign practice when necessary. All I say is that we ought to benefit by the experience abroad, and I know that those who have the best interests of electric lighting in England at heart agree with me.

This neglect of the principles laid down in other countries I find to exist whether the central station be used for continuous or alternating currents. I foresee great danger in store for us if we do not discuss the difficulties fully at the outset, and I trust that the discussion that this part of my Paper will give rise to will assist to make the progress now being made in England a thorough success.

Three-Wire System.

My first remarks will be about the direct system of supply at low pressure—a system which may be much more frequently employed with advantage than many people seem to imagine. It is not suited for a large district, but it has some advantages.

First. That the steadiness of the light can be increased, the fear of accidents diminished, and the amount of machinery reduced, by the employment of storage batteries.

Second. If batteries are not used the loss of energy in transformation is avoided.

* This Paper was divided into two distinct parts, of which the portion we print this week forms Part II.

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Let us deal first with the case where all the dynamos are working in parallel at the same pressure. This is the Edison plan, and is very generally adopted. I have shown in my Cantor Lectures* that when we extend beyond a certain distance from the central station on the system at present used, the question of economy, as established by Sir William Thomson's law for the size of conductors must be partially abandoned, and a different size used, in order to prevent the variation of electrical pressure over the area being too considerable under the varying loads. With the "two-wire" system the law of economy holds only up to a very short distance; with the "three-wire" the distance is doubled. This is due to the fact that the pressure is doubled, and this is the principal advantage possessed by the three-wire system. In Berlin and Milan the two-wire system has hitherto been adopted, and the enormous amount of capital expended in copper is a proof of the costliness of the system. I hold that in no case of central station work at low pressure ought the two-wire system to be adopted. In this I am supported by the universal practice in America, where the two-wire system for low-pressure distribution is now totally abandoned. I am also supported in this by the practice in Berlin, where all future work is to be done on the three-wire system. In spite of these considerations, I am not aware of a single case where it is in actual use in England since the experiments at Leamington have been abandoned. The two-wire system is used at a good many places in this country. The result of experience probably is that the three-wire system can be profitably worked to a maximum limit of half a mile where the price of gas is over 5s. per 1,000 cubic feet; beyond that distance the profits diminish too much. In London I do not think it could be well done beyond 400 yards, as a general rule.

Feeders.

I now come to another principle of distribution which is strangely, and I believe almost universally, neglected in this country. I refer to the use of "feeders." Let me distinguish between the use of feeders and mains. Mains are conductors from all parts of which branches may be laid into the houses. Feeders are conductors leading from the central station to various points in the system of mains, and which are not tapped on the road. In Berlin and Milan the practice, first started in America, is followed of laying down a network of mains and supplying current at numerous points in them by means of feeders. This serves to equalise the pressure over the entire districts under varying loads In England this practice is not generally adopted. The result is that if you wander over a district supplied by electric light in England, you find that when the supply of current is small the lamps are equally bright over the whole town, but when there is a large demand for light the glow lamps near the station are far too bright and those at a distance are far too dull. In Berlin, where half the capital spent in conductors has been used for feeders, the lamps are, all over the district, equally bright at all times. Not the slightest difference can be perceived at different hours of the day or night. I hold the opinion that a station with low-tension current without feeders is badly engineered.

Using Dynamos at Different Pressures.

It is the universal practice abroad to make the size of the feeders such that the loss of pressure in these feeders is the same in all. This involves the use of very large feeders when their length is great, and great waste of energy when the length of feeder is small, but it enables all the feeders to be supplied by dynamos at the same pressure, which may therefore work in parallel. This arrangement is simple to work, but it is wasteful. I find that we can save enormously in copper at a slight extra trouble in working the central station. I would prefer to see the feeders divided into two or three groups, feeders in each group having the same length, and having the same loss of pressure. All these feeders would be made of the economical section, according to Sir William Thomson's law. When the station is at full load the dynamos working long feeders have a higher pressure than those working short feeders. When the load is light all the dynamos would work at the same pressure, because the loss in the feeders is insignificant. At such time all the dynamos might be joined in parallel, or the feeders might all be upon one dynamo.

Position of Pilot Wires.

In nearly all cases of low-pressure distribution the pressure is regulated by a "pilot wire" coming from the point where the feeder meets the main. These pilot wires indicate the pressure at those points upon a voltmeter, at the station, which is kept at constant reading by an attendant. Sometimes all the different pilot wires are grouped together at the station and indicate the average pressure on the voltmeter. This is done at Berlin. At Milan, however, the pressure is varied according to a tabular rule when the current varies. The use of pilot wires is, however, very desirable, but I hold that hitherto the pilot wires have generally been placed in the wrong position. Suppose that a 4 per cent. variation exists over the district of mains supplied by any one feeder, and that the point where the feeder strikes the mains is kept at constant pressure, then the most distant lamp supplied by that feeder has a variation of 4 per cent. If, however, the pilot wire came from a point half way between the most distant lamp and the feeder, and this point were kept at constant pressure, the maximum variation of pressure would be reduced to one-half, and would be only 2 per cent. It appears, then, that by properly placing the pilot wires the variations in pressure can be reduced to one-half; or, keeping the variations of pressure the same, the quantity of copper in the mains may be reduced to one-half.

In these suggestions as to dynamos at different pressures and as to the position of pilot wires I am supporting a course which has not been generally adopted anywhere, but the improvement ought only to be mentioned to receive general recognition.

Lamps of Different Voltage.

It has often been proposed to supply different parts of a district with lamps of different voltage. In the ordinary plan of using feeders and pilot wires the maximum pressure at the most distant lamp supplied by any feeder is the same as the pressure in the mains at the feeder. The minimum pressure may be, let us say, 4 volts less. Suppose 100-volt lamps are used, those near the feeder will always have 100 volts, but the most distant ones will have pressures varying from 96 to 100 volts. 96 volts would make the lamps very dull; and if at the distant points lamps of 98 volts were used, the pressure would never vary more than 2 per cent. from the normal, and a better light would be obtained. This would be a very good arrangement if we could lay out a district from the beginning with all the positions of the lamps established, but it is found that as the station progresses a house which would have required 100 volts yesterday may require a limit of only 99 volts to-day, owing to the introduction of additional lamps between it and the feeder. Experiments which have been made in America on this plan have led to disastrous results and hopeless confusion in completing the scheme. This plan has been completely abandoned, and in the present state of the industry I think that this abandonment has been wise.

I do not think a greater variation of pressure than 2 per cent. up and down should ever be allowed if you wish to supply a satisfactory light.

I consider that success or failure of many electric light companies now doing central station work is very much dependent on their following or neglecting the proper rules for distribution, and I will illustrate the importance of these rules by a few examples.

1. A plain network by the two-wire system, fed at the central station with the economical size of copper conductors according to Sir William Thomson's law, say, of 1,000 amperes per square inch, and going to a distance of 480 yards, would have a difference of pressure to which the distant lamps would be subjected of 24 volts.

2. On the three-wire system this would be 12 volts with one-fourth extra copper.

3. With the same amount of copper as in the last, properly arranged with feeders, the feeding points being 160 yards apart, the maximum variation of pressure in any lamp over the district is two volts if the pilot wires come from the feeding centres.

4. Everything remaining the same as this last, except that the pilot wires are placed in the proper position instead of at the feeding points, the maximum variation is only one volt.

Putting it in other words, the quantity of copper required to limit the variation of pressure over the district to a certain figure is in the last case one-twelfth part of what it is in the second case, and one-nineteenth part of what it is in the first case.

High-Pressure Distribution.

Before I leave the question of distribution, let me now apply the same rules to the "Gaulard and Gibbs" system of using alternating currents with high pressure in the mains and low pressure in the houses, the reduction in pressure being effected by means of an induction apparatus called a "converter." At the present moment these converters are usually put in parallel upon the mains. There is a general impression in this country that it is not necessary to have feeders supplying the mains, even though the distance extends to several miles. Here again the experience of other countries has been set at defiance, although in a large town like London the importance of this rule is greater than in most American cities, or in Rome. If such views continue to be adopted, the result will be as disastrous in the future as it has been in the past. In the most extensive system in this country, when there is a large demand for current, the distant lamps look like red-hot hair pins, even though the near lamps be at full brightness. This is due to defective distribution.

As already stated, there is a general belief in this country that to whatever extent the Gaulard and Gibbs system is used no trouble comes from variations of electric pressure over the district, even when the converters are placed in parallel. Let us look at this

* Cantor Lectures, "On the Distribution of Electricity," Society of Arts *Journal*, 1885.

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question a little closer. Returning to the two-wire system for low pressure, if we use 1,000 amperes to the square inch as the economical section for our conductors, the fall in pressure is 5 volts for 100 yards; the loss of pressure due to the house wiring amounts very generally to 2 volts, hence the total variation between the periods of maximum and minimum output is 7 volts per 100 yards, or about double what is permissible (4 volts); hence, with the two-wire system such a size of conductor at 100 volts pressure could only be used for a distance of 57 yards. Let us see how this distance is extended by using a pressure of 2,000 volts in the mains and 100 volts in the secondary. With the same density of current the loss of pressure in the house will be now 5 volts for 2,000 yards, to which must be added 2 volts for the house wiring and about 1½ volts for loss in the converter, making 8½ volts loss of pressure in 2,000 yards.

If we allow 4 volts variation in the lamps, which is quite a maximum, this allows only ½ per cent. variation in the mains, and then the greatest distance to which conductors can extend is 200 yards. The only means of extending the district is by the use of feeders. In America the practice prevails of allowing only ½ per cent. loss of pressure in the mains. I have taken a concrete case of 1,000 amperes per square inch, which may not always apply to actual conditions, but it shows the necessity of adopting the universal foreign practice of employing feeders even with high-pressure mains.

Pressure Indicators on High-Tension Circuits.

It would be highly inconvenient to use pilot wires with the Gaulard and Gibbs system, such as are used on low-tension circuits; for this reason compound-wound voltmeters are used, which indicate the pressure at the far end of the feeder. I have described those in use at Rome and Milan; I have also described elsewhere those used by Westinghouse in America. The principle of these indicators is to have one winding connected like an ordinary voltmeter with the terminals of the dynamo, and another winding in reverse direction to carry the main current. The diminution in the indication owing to this second winding is always equal to the fall of pressure in the feeders. Different inventors have applied different classes of apparatus for accomplishing this result, but it is needless to say that the working out of such instruments takes a long time, more especially in such an instrument as that employed by the Westinghouse Company, which is made interchangeable for all circuits by the insertion of six different plugs, representing six different losses in the feeders, converters, and house wiring, varying from 3 per cent. to 10 per cent., besides four plugs for the different maximum currents in use with any feeder. I draw attention to this point because I consider that the successful working of such a central station depends largely upon the use of such an indicator of pressure; and I find manufacturers in this country who have had little or no experience in central station work prepared to equip central stations with all the necessary measuring instruments, and I wish to feel confidence that these manufacturers have realised the importance of such instruments; and I wish earnestly to impress upon them, solely in their own interests, the necessity of working out such instruments if they wish to redeem electric lighting in the metropolis from the condition into which some of the so-called pioneers of this industry have reduced it.

Insulation.

We have now to consider a very important, and perhaps the most difficult, part of the problem of central station lighting—How are we to preserve our insulation? It must be noticed that we do not require a high insulation for the sake of getting a small loss of current, but only because with many insulators the high insulation is more permanent, and permanency is the quality of insulation which is most to be desired. I am not going to discuss at present the whole question of insulation, but rather to draw conclusions from the experience of the past. At the present moment vulcanised india-rubber and okonite are the substances which have the highest reputation for durability and high insulation under all conditions. These, like other cables, are sometimes covered with lead, but in their case it is only as a mechanical protection, especially during the process of laying, because the destruction of the lead would not destroy the insulation. Of late years a class of cables has been much praised about which I wish to speak. The copper conductor, stranded or otherwise, is covered with any fibrous material, preferably jute, impregnated with bituminous oils. This covered core is enclosed in the lead pipe. In this class of cable the insulation depends upon the lead being water-tight. We all know of many places where this type of cable has done good work for a limited time, and many of us were inclined to believe that it was quite satisfactory; but I think I am right in saying that none of us know of its having worked successfully in any place for three or four years. I have said that a cable of this kind has hitherto been exclusively used in Berlin, the lead being covered with layers of tape or braid soaked in a preservative compound, and the whole armour-plated with two closed spirals of iron ribbon. I regret to have to tell you that this insulation has been a failure. It goes on well enough for about three years, then the lead gives way, the covering on the copper is permeated, and chemical or voltaic action sets up in the copper, which itself becomes disintegrated. So far as experience goes, this type of cable seems to me to be unsuitable for permanent work with the electric light. I trust that in the discussion we shall have some facts brought out. I had hoped, from what Berthoud and Borel, and also Waring, had done, that this would not be so, but the Berlin experience leads me to think otherwise; and on looking through the testimonials of makers I do not find that these cables, when placed underground, have ever worked electric light circuits beyond the three years fixed by the Berlin people as being destructive. I have been told, but I cannot believe it, that there is one company in London actually proposing to put such lead-covered cables without covering into iron pipes. Of course everyone knows they would soon be eaten into by galvanic action.

At Berlin and elsewhere I believe there is the intention of trying some modification of the system of using bare conductors, first practically used by Mr. Crompton at South Kensington. Taking economy into account, it is probable that for low-tension circuits this is an admirable plan. It is probable that it may also be adapted to high-tension circuits by using oil insulators to support the bare conductors. When copper strip is used it is necessary to raise the cover of the trough in order to increase the number of the conductors: this is very expensive. For my own part I would prefer a drawing-in system if it were otherwise equally good.

No information has ever been given as to (1) the maximum or (2) the minimum insulation resistance of the conductors at Kensington Court, but perhaps this information will be given during the discussion.

At the present moment it seems to me that the only types of underground cable proved suitable for permanent work are either bare copper supported on insulators, or else vulcanised india-rubber, or perhaps okonite. Especial care must be taken to avoid an insulator which is injured by the gases which permeate the soil of a town, or which has the property, like pitch, of becoming viscous, and so letting the copper become decentralised.

Meters.

The next lesson which the experience of foreign stations in Europe and America has taught us is the importance of charging the consumers of electricity by meter, like gas. I find that at present most companies in this country are charging the larger proportion of their consumers by contract, making an annual charge for each lamp. This appears, from evidence collected everywhere, to be a fatal mistake. It is the universal experience that those stations pay best where meters are used. In many stations it is found to be the best plan to make a fixed annual charge, which may be put down as the rent of the meter, and then an additional charge proportionate to the quantity of electric current supplied. This has the advantage of preventing customers putting in place a large number of lamps which during the greater portion of the year are idle, but which on festival occasions may all require current. Such idle lamps are very expensive to the suppliers, because a large reserve of machinery must be lying idle during the whole year to be ready for such occasions.

Within the last month I have described before the Society of Arts* the different meters which are valuable, without pretending to estimate their relative value. For continuous currents we have the Edison and Aron meters, for alternating currents we have the Schallenberger meter, and for both classes my own "Windmill" meter.

Converters.

The induction apparatus used with alternating currents is called a "converter," "secondary generator," or "transformer." The reduction of pressure from the primary to the secondary circuit is generally 20 to 1, but sometimes more. A large number of types have been invented. I have elsewhere described the Westinghouse converter, which I have tested and found to be very efficient, even though the largest one he is in the habit of supplying is only for forty lights.

Only the larger size Zipernowski converter is so efficient. Three sizes are made, varying in efficiency from 95 down to 88 per cent., though the latter is a converter suitable for twenty-five lamps. Many of the types which are made in England I feel sure are far from efficient. There is a general opinion that the loss in the converter is necessarily small. This is by no means the case. A great deal of care must be taken in the design to get a satisfactory result. I think there is a general idea that any of the converters now on the market in England will give an efficiency for the average number of lamps in circuit of about 90 to 95 per cent. I should be much surprised if there are more than two types in use in this country which have an efficiency for the average number of lamps over 70 per cent. Yet, so far as I am aware, no maker in this country ever tests the efficiency of the converters which he supplies. The effi-

* *Society of Arts Journal*, January 25, 1889.

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ciency of a converter falls when it is under-loaded. If the converter in a house is adapted for 100 lamps, and only three or four lamps are in use, then, with many converters, the current which is being used is double or treble what is required for the lamps. This defect in some converters is clearly shown in the load diagram of the Grosvenor Gallery installation, where during the hours of minimum supply the current sent out from the station is seen to be abnormally high—far above that of the load diagram of other central stations—and at the hours from 4 to 6 a.m. in October current sufficient for 4,000 lamps is indicated on the station meter. This curve shows a loss of 20 per cent. The type of converter which Westinghouse has perfected is one of low magnetic resistance. The worst ones now being made in England are of high magnetic resistance. The waste in a converter, independent of magnetic friction, varies as the square of the magnetic resistance.* The waste due to magnetic friction also varies as the square of the magnetic resistance if the weight of iron is constant and the induction in the iron is the same. These high magnetic resistance converters require a great deal of copper. The magnetic friction is so great that they would probably work better with an open magnetic circuit, as shown by Lord Rayleigh (*Phil. Mag.*, 1886).

Slow and High Speed Engines.

I need hardly tell you that the most startling difference I found between the best European and American practice is the question of speed of revolution of dynamos. In America 1,000 revolutions a minute is the normal speed for an alternator of 250 horse-power; in Rome the 600 horse-power dynamos revolve at 125 revolutions per minute; at Berlin the 400 horse-power engines at 80 revolutions per minute. In Europe there is a tendency to condemn high speed as such, whereas high speed is more objectionable only in the type of machine where the revolving part is more massive, less perfectly balanced, less capable of standing centrifugal strains, and has a longer distance between the bearings. In every other point high speed is an advantage, especially in economy of plant. Now compare the Zipernowski and the Westinghouse dynamos, choosing of the former the one without Pacinotti teeth on the armature, as made by Elwell-Parker. These two machines are electrically identical, but in one the armature is fixed, in the other the field-magnets. The armature can, and the field-magnets cannot, be perfectly balanced. The weights are not very different. The armature is more capable of standing centrifugal strains than the coils of the field-magnets. For all these reasons the Westinghouse may be run at high-speed and gain all the advantages of economy. Of course the necessity of introducing belting has to be considered in this case. But then turn to the Parsons alternator, which drives direct, and being the lightest, best-balanced machine, with great capacity of resisting centrifugal strains, and with the only scientific bearings in the market. Here we have a machine where all the advantages of high-speed may be safely acquired and great economy introduced. People are apt to forget that slow speed means large machines with no increase of output.

Speed of Alternations.

Now I come to a very important point. What speed of alternations shall we use? In Rome they have 83 alternations, or 41 complete periods, per second. In America the Westinghouse Company have 267 alternations, or 133 periods, per second. What are the advantages and disadvantages, and why have these makers adopted different plans? I will answer this in detail to the best of my ability. First, Westinghouse went to rapid alternations because he wanted his converters to be of reasonable size. Second, he wanted to economise plant by using high speeds, and it would be very difficult to have slow alternations with high speed. Third, Ganz and Co. (Zipernowski) wanted to drive their machines at slow speeds, under which circumstances they cannot easily get rapid alternations. This is how these things were arrived at. Now let us see what the results are.

1. With rapid alternations the size and cost of the converters is diminished. Most people seem to think this is a small matter. A moment's consideration shows that it is not so. It is found that in most houses the size of converter does not exactly fit the number of lamps, so a size larger must be used. Hence, for a 7,500-light plant converters for 10,000 lights are required. The price of these, for the sizes used in houses, is (as the average of many makers) £5,000. The cost of engines and dynamos combined (Parsons) for the same would be about £6,000. You will now see that the cost of converters is as important as anything else.

Mr. Kapp has stated, I venture to think erroneously, that the size does not vary with the speed of alternations. This is opposed alike to experience and theory. Westinghouse knows this. I am informed that Mr. Ferranti knows it, and Mr. Zipernowski has told me so in a recent letter.

2, There is, however, an important gain by slowing the alternations. It is then easier to work in parallel. This is due to the fact that the machines have more time to get into step. If I considered parallel working essential to success, I should say, "sacrifice the cost of converters, and use slow speed." Otherwise I should say, certainly and without hesitation, "Use rapid alternations to increase the efficiency and economy."

Working in Parallel.

The experience of Rome is encouraging to anyone who thinks parallel working essential. For my part I do not. Sub-division of mains is far more practical in most cases, and enables you easily to cut out special districts if a fire or other trouble occurs. It also gets over the trouble of increased resistance in large conductors with alternating-current, dwelt on by our President in his opening address. If I have more than one station in a town, and I want one to assist the other, I would do so by trunk lines between the stations, to which a dynamo can be attached at one end and feeders at the other. Of course both stations must supply the same type of converters; hence in such a system it would not do to use dynamos of various speeds of alternations at the different stations. I would certainly prefer parallel working as being simpler for the men at the central station, if no complications are introduced to make the machines work in parallel, and if the system were equally economical, but I do not consider it at all essential. I venture to think, however, that the plan now universally proposed for making machines work in parallel will not long be tolerated. This is to introduce into the machine a large amount of injurious self-induction, thus diminishing the plant efficiency and rendering the equalising of pressure with varying loads very difficult. I have confidence in the ingenuity of our inventors, who will soon devise a less objectionable plan.

Automatic or Hand Regulation.

The question now arises whether the regulation of potential should be accomplished by hand or automatically. In all low-pressure systems, such as Berlin, it is done by hand. A workman soon gets to know at what hour special attention must be paid to this, and on the low-tension system with shunt-wound or compound-wound machines the regulation required is slight. Where the saving in attention is not very great it is always unadvisable to trust to automatic dodges. The case of alternating-current dynamos with high self-induction is very different, for the electric pressure then varies enormously with the current. In this connection such a machine resembles a series-wound direct-current machine with high resistance. The changes are so great that some automatic adjustment is necessary. Ferranti, Lowrie and others have used the sagging of a wire to effect this, and they regulate the pressure at the dynamo, not at the centres of distribution, which is wrong. The apparatus looks too delicate for an engine room. But Ganz and Co. use a very practical type. They also regulate for the centres of distribution. I also prefer the method used by Ganz and Co. of regulating the large changes by hand, and only the smaller changes automatically. This is necessary, owing to the very large adjustments necessary with alternators of high self-induction.

In conclusion, I feel confident that all those who are working to maintain England's supremacy in this department of industry will agree with me that the practical details necessary for successful central station working must be thoroughly well thought out beforehand, and that much saving of time and money can be effected by gathering hints from those who have spent years of time and tens of thousands of pounds on these details.

I frankly admit that I have learnt more that is of practical value in this line from the inspection of actual work done than by reading books.

But we must remember that the low price of gas in England, the cheapness of coal, and the relative cost of labour, all introduce special factors which will partially differentiate the English practice either from that of the continent of Europe or of America.

I wish now that the last words of this Paper may be words of thanks to the gentlemen in other countries—whether in Europe or in America—who have the control of central stations for the courtesy which they have extended to me in my endeavours to assist, to the feeble extent possible to me, in maintaining the position of this country in the progress of this new and important industry.

* See my formulæ for converters, *Journal* of the Society of Telegraph-Engineers and Electricians, Vol. XVII., Part. 71, p. 153.

REVIEWS.

L'Électricité a la Maison. By JULIEN LEFÈVRE. (Paris: J. B. Baillière et Fils.)

It will be gathered from the title, and still more from the preface, that the author of this work intends it for the consumption of amateurs; hence the prominent position assigned to primary batteries, electric jewellery, and "*danseuses élec-*

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triques à solenoide." The contents are multifarious to a degree unusual even in books intended for the amateur; in fact, we venture to think that its sphere of usefulness would possibly have been wider had the ground covered been less extensive. In a work ranging from Gramme machines and Belleville boilers to microscopic electric tie-pins there is likely to be a considerable amount of undigested and indigestible information. We can only recommend "L'Électricité à la Maison" to amateurs of an encyclopædic cast of mind.

Gleanings in Science: a Series of Popular Lectures on Scientific Subjects. By GERALD MOLLOY, D.D., D.Sc. (London: Macmillan and Co., 1888.)

This series of lectures affords a favourable specimen of the "popular" treatment of scientific subjects. Dr. Molloy possesses a lucid and picturesque style, and he succeeds in being at once entertaining and accurate. The lectures were delivered (on several different occasions) at the invitation of the Royal Society of Dublin. The subjects dealt with are—Latent Heat, Lightning and Lightning Conductors, The Storing of Electrical Energy, The Sun as a Storehouse of Energy, The Electric Light, and The Glaciers of the Alps. The lecture on the storage battery was delivered in 1882; it contains a good *résumé* of the general principles involved, though it is not unnaturally tinctured with what has since proved to be a too roseate view of the future. This, however, is set right by a very fair and accurate summary of the subsequent history of the accumulator down to the middle of last year. Similarly, the two lectures on Lightning were delivered in 1881, but an Appendix is added, in which the recent discoveries of Dr. Lodge and also *The Electrician* report of the discussion at the Bath Meeting of the British Association are very well summarised. The volume should amply fulfil its purpose of both interesting and instructing the general reader in some of the most important of the recent developments of Physical Science.

Notice sur le Concours 47. Électricité. (Brussels Exhibition of 1888.) (Brussels: Imprimerie des Travaux Publics.)

This is a pleasantly written account of the principal electric exhibits at the recent Brussels exhibition, and the volume forms a useful work of reference on the subject. The electric lighting of the exhibition buildings and gardens is gone into at considerable length, and several pages are devoted to the description of the remarkable display made by the military telegraph department of the Belgian army. The Dejongh telephone transmitter is alluded to in very eulogistic terms, but unfortunately no technical details are given. Under the heading of lightning conductors, the apparatus devised by M. Curtoy for the purpose of exhibiting to popular audiences some of his most striking lightning rod experiments is described at great length. Amongst other results, M. Curtoy shows that "Ohm's law with regard to electrical resistances no longer holds in the case of sparks of high tension," and that "a lightning conductor can still act as a protector even when there is a small fracture in it." "We are happy to mention in this connection," the writer goes on to say, with patriotic pride, "that quite recently the English *savant*, Dr. Oliver J. Lodge, described, in a Paper read before the Society of Arts of London, experiments confirming those of Melsens and Curtoy, and he came to the conclusion that Melsens' lightning conductor is that which complies best with indications given by theory." The book concludes with the mention of an interesting long distance indicator at Antwerp, which shows the height of the waters of the Scheldt at four different points on its banks.

The Voltaic Accumulator. By ÉMILE REYNIER. Translated by J. A. BERLY. (London: E. and F. N. Spon.)

This is a translation of M. Reynier's book on accumulators, a review of which appeared in our issue of October 19, 1888. The translation is not very well done, but as regards typography the English work is certainly a finer volume than the French original.

Electricity in the Service of Man. From the German of Dr. A. R. VON URBANITSKY. Edited by R. WORMELL, D.Sc., M.A. (London: Cassell and Co.)

This is an edition in monthly parts of the work which was reviewed in our issue of February 4th, 1887.

Index of Publications on Methods of Communication in the Field, and on Torpedo Warfare. By R. VON FISCHER TREUENFELD. (London: H. Alabaster, Gatehouse and Co.)

The great and increasing attention which is now being given to electrical communications in the field by the military authorities of Europe has naturally given rise to a voluminous literature on the subject, and it is with the laudable desire of facilitating the mastery of this important subject by military men that the author has devoted himself to the laborious task of compiling an index of publications. The work seems well up to date, and its value is greatly increased by a classification of the publications under no less than 29 heads, in addition to a most useful index to authors. We trust that the compiler will meet with sufficient encouragement to induce him to keep the index always up to date.

The Model Engineer's Handy Book. By PAUL N. HASLUCK, A.I.M.E. (London: Crosby Lockwood and Son.)

As the author remarks in his preface, "model engineering is a branch of the mechanical arts that has received but a scanty share of literary treatment." We do not think, however, that this can any longer be said. A perusal of Mr. Hasluck's useful and well illustrated little book of some 140 pages ought to teach something of model engineering, even to Macaulay's schoolboy.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, March 8th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Notes on Mining in Spain, with special reference to the Lead Mines of Linares." By C. F. SMITH, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "The Discharge of a Leyden Jar." By Prof. OLIVER LODGE, F.R.S.

SATURDAY, March 9th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

PHYSICAL SOCIETY.

3 p.m. (1) On the Magneto-Optic Rotation by Transient Currents, with reference to the time required for the production of the effect. (2) On an Electrostatic Field produced by Varying Magnetic Induction. (3) On Some Experiments allied to those of Hertz. (4) On the Velocity of Electric Pulses along a pair of Isolated Wires. (5) Sundry Laboratory Notes. By Prof. OLIVER LODGE, F.R.S.

MONDAY, March 11th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture IV., 2. "The Decoration and Illustration of Books." By WALTER CRANE.

TUESDAY, March 12th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "Indian Railways: the Broad and the Metre Gauge Systems Contrasted." By F. J. WARING, M.I.C.E.

WEDNESDAY, March 13th.

CITY AND GUILDS OF LONDON INSTITUTE OLD STUDENTS' ASSOCIATION.

7:45 p.m. General Meeting at the Finsbury Technical College. "Theory of the Chamber Process." By Dr. G. F. MOODY (Member).

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Aluminium and its Manufacture by the Deville-Cattner Process." By WILLIAM ANDERSON, M.I.C.E.

THURSDAY, March 14th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture, "The Venom of Serpents and Allied Poisons." By SIDNEY MARTIN, M.D., B.Sc.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "Some Electric Lighting Central Stations in Europe, and their Lessons." By Prof. GEORGE FORBES, M.A. (Member).

FRIDAY, March 15th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse, "Beacon Lights and Fog Signals." By Sir JAMES N. DOUGLASS, F.R.S.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 499
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Illustrated. Continued 504
Siemens' Recording Apparatus for Compact Morse Writing-Patent. Illustrated 505
The Institution of Electrical Engineers.—"Lessons to be Learned from Foreign Central Station Lighting." By Prof. G. Forbes, F.R.S. 505
Reviews 508
Meetings of Scientific Societies. 509
The Gaulard-Gibbs and the Jablochkoff Transformer Patents 510
Economics of Planning and Constructing Electric Light and Power Stations. By Alex. P. Wright. Illustrated 511
Physical Society.—"Electrical Measurement." By Profs. Ayrton and Perry. Illustrated. Concluded 513
On the Designing of Continuous-Current Dynamo Machines. By Prof. Jamieson, M.I.C.E., F.R.S.E. Illus. Concluded. 515
Legal Intelligence—
In re Gaulard and Gibbs' Patent.—Appeal. *Judgement* 516
American Notes 518
Notes from Germany 519
Correspondence—
The Periodicity of Earth-Currents.—A. H. Bengough 519
The Insulation Resistance of Installations.—T. W. W. Melhuish, A.M.Inst.C.E. ... 520
Enamel as an Insulator.—F. H. 520
Globular Lightning.—J. Van Moorsel 520
Electric Lighting Companies at Kensington.—H. St. John Winkworth 520
Companies' Meetings, &c.—
The Brighton and Hove Electric Light Company (Limited) 521
Anglo-American Brush Electric Light Corporation (Limited) 521
New Companies Registered ... 523
City Notes, &c. 523
Companies' Share List 524

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THE GAULARD-GIBBS AND THE JABLOCHKOFF TRANSFORMER PATENTS.

The judgment of the Court of Appeal in the case of Ferranti *versus* Gaulard-Gibbs can hardly have surprised any one who is at all conversant with the facts of the case. In the Court below Mr. Justice Kekewich, in pronouncing the decision annulling the patent, expressly based that decision upon a point of law, and while he certainly did express a somewhat adverse opinion both as to the novelty and as to the utility of the invention, it was the legal objection alone which led to the evidence of the patent. The Lords Justices of the Court of Appeal, whilst distinctly inclining to a more favourable view upon the points of novelty and utility, were yet entirely at one with Mr. Justice Kekewich in pronouncing the patent "hopelessly bad in law."

The specification, as originally filed on March 13, 1883, was admittedly confined to the construction and use of a particular type or types of secondary generator, which types are now, however, admitted to be commercially valueless. But the attempt made in 1886 to amend the specification by striking out the claim for a particular construction, and so extending the interpretation to the employment of any transformer, however constructed, in combination with an alternating current dynamo of high electro

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motive force, traversed one of the fundamental principles of patent law. To permit a patentee, after the issue of the patent, indefinitely to enlarge the boundaries of the domain within which he holds a monopoly, would obviously open the door to unlimited abuses, and would, in fact, render the patent law impracticable. The fact that a patentee may chance to lose the reward to which he is justly entitled merely by the unskilful drawing up of his specification is one of those contingent misfortunes for which the law is obviously unable to provide a remedy.

Whether the present instance affords an illustration of such substantial though unavoidable injustice we need not now stay to discuss; we have several times already expressed an opinion upon the technical aspect of the work of GAULARD and GIBBS, and need only add that it has always seemed to us that, whilst the indirect results of their labours have been of almost inestimable value to the electrical engineer, yet the invention itself possessed little of originality, and, if it be judged by the specification, still less of intrinsic merit. It should be some consolation to the patentees to know that the Court of Appeal attaches a higher value to the technical aspect of their work than does the great majority of the electrical profession.

The practical importance of this decision, so far as its influence upon the manufacture of transformers in this country is concerned, is, however, very much discounted by the announcement now made in connection with the JABLOCHKOFF patents of 1877. Just twelve months ago (*The Electrician*, March 9th, 1888) we called attention to the fact that M. JABLOCHKOFF was entitled to the credit of having first suggested the use of a closed iron circuit in connection with an apparatus which would now be called a transformer, and was, in fact, used by the inventor for the very same purpose. In a subsequent patent (No, 1,996) of the same year, 1877, M. JABLOCHKOFF more clearly and explicitly described the system of distributing electricity by means of induction coils supplied with alternating currents. The second claim of this specification runs as follows :—

"The use in apparatus for the production of electric light, of induction coils, interposed in a primary electric circuit for generating separate and independent currents, to be used for producing electric light in one or more lamps interposed in such secondary circuits substantially as herein described."

In the drawings attached to the specification three induction coils are shown, having their primaries connected in series, and each with different numbers of Jablochkoff candles connected in series in the secondary circuits. The induction coil, or transformer, is explicity stated to be of the pattern described in the earlier patent, which, as already stated, has a closed magnetic circuit; in fact, its general design bears a close resemblance to some of the transformers in use at the present day. M. JABLOCHKOFF also contemplated having as many secondary coils as there were lamps to be lit, in which case he says "each lamp is perfectly independent and may be lit or extinguished separately." The specification concludes with the following sentence :—"As a great number of induction coils can be placed in the circuit and as a number of lamps may be placed in the circuit of each coil, it will be seen that the electric light is thus capable of very great subdivision." Altogether, apart from any controversial matter, we feel sure that every electrician will agree with us that the man who twelve years ago, and six years before the date of the Gaulard-Gibbs patent, could foresee to this extent the modern methods of electrical distribution, is worthy of our highest admiration.

Coming now to the actual state of affairs, it is already pretty generally known that the Jablochkoff patents are the property of the United Electrical Engineering Company, of which Messrs. MANVILLE and MADGEN are the managing directors. As soon as the possible value of the patent in question became apparent steps were taken by these gentlemen to obtain counsel's opinion as to its precise interpretation. A joint opinion has been given by Mr. J. F. MOULTON, Q.C., and Mr. J. C. GRAHAM (who, it will perhaps be recollected, were engaged upon opposite sides in the recent action). In this document, after pointing out that the date of the patent is prior to that of the introduction of incandescent lamps or of any lamp capable of being run in parallel, they proceed as follows :—

"We are therefore of opinion that his [Jablochkoff] claim includes any arrangement in which secondary generators of any construction are placed in parallel as well as in series, and that it also includes the use of any kind of lamp whatever, of the incandescence type."

Armed with this opinion, Messrs. MANVILLE and MADGEN were obviously entitled, had they been so inclined, to assume an attitude which would in all probability have led to further squandering of time and money in litigation, from which, as usual, the lawyers would have derived the chief benefit. On the other hand, they might have succumbed to the temptation—which did not fail to present itself—to allow their interest to pass into the hands of persons who would have pursued the advantage to the uttermost. It is, we think, very greatly to the credit of Messrs. MANVILLE and MADGEN that they did nothing of the kind. On the contrary, they have approached the trade in the most conciliatory spirit, and by dint of a tact and patience, which we cannot too much praise, the difficult and delicate negotiation which ensued were brought to a conclusion which is satisfactory to all concerned. Licenses have already been taken out by several of the leading manufacturers, and we have no reason to doubt that others will follow suit. We believe that the terms which have been made are such as to afford a fair and reasonable recognition of the supremacy of the Jablochkoff patent without pressing at all onerously upon the development of the industry. The fact that it has been possible to arrive at such a settlement by purely private negotiations speaks well for the spirit of fairness and honourable dealing which has animated all concerned.

ECONOMICS OF PLANNING AND CONSTRUCTING ELECTRIC LIGHT AND POWER STATIONS.*

BY ALEX. P. WRIGHT.

That the general application of electricity to lighting and power are to come into almost universal use is a reasonable prediction, although at present the management of a great many electric light and power companies do not appear to care for its general use, and indeed often openly say so and seek to pick and choose their customers. The time is rapidly drawing near, and, indeed, has already come to many companies, when the customers, who will use electric light or power at the present prices, will become exhausted, and the only field remaining, an extensively wide one, will be the householder, the small storekeeper, and even the mechanic or labourer in his two or three rooms—a field almost unlimited. To control this field it will be necessary to produce electric currents and to distribute them at lower rates than at present, and as important as cheap production is the prevention of the immense losses and leakages which occur, in the average of the electric plants of to-day, from expensive handling of fuel, bad firing, poor insulation, insufficiency of copper, and so forth. The savings which might be made in many cases, and the losses which might be prevented, would together pay handsome dividends on the outlay necessary for wise reconstruction, and had the planning and construction in the beginning been wise the savings would be much greater.

These articles are intended more particularly for the promoters of new companies and the directors of existing companies requiring or about to commence the extension or remodelling of their plants.

* From *Modern Light and Heat*, Boston, U.S.

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Among the causes of loss and want of economy are the following :—

1. Bad location of plant, with regard to fuel and centre of distribution.
2. Cost of handling fuel.
3. Bad firing.
4. Cost of water.
5. Friction and loss in transmission of steam and mechanical power.
6. Bad designing and division of power and current generating units.
7. Loss from insufficiency of distributing copper.
8. Leakage from use of poor insulation and poor construction.
9. Unwise rates and discrimination as to selection of customers calculated to head off profitable business. All more or less due to false economy in purchase of material and construction.

The first consideration in organising for the lighting of a town or city is the determination of the requirements, as far as present and near future lighting are concerned, both as to the number of lights and the duration and times of their use, bearing in mind that the consideration of future business does not of necessity mean immediate expenditure, but rather the prevention of large expenditures when the time comes for extension, and that removal of a whole plant or reconstruction of the original plant may not be necessary to accommodate extension. These considerations are necessary in order that the amount of apparatus may be determined and a preliminary plan and sketch made as a basis upon which to estimate the capital required for the enterprise, and in order that the probable cost of maintenance and running expenses may be arrived at, with a view to the preparation of a schedule of rates which, whilst profitable to the company may be equitable to the consumer, and of such a nature as to bring business.

The choice of a site for the location of an electric light or power station requires great judgment, and it is here that usually one of the strongest evidences of false economy exists. A very general idea has been that any place would do for an electric light station as long as it was cheap, and so it would not matter where located, or at how low a rate purchased, if subsequent cost is to be disregarded. Primarily, secure a location immediately adjoining coal transportation, and, if possible, water, chosen with a view to the economical handling of fuel, as well as room for abundant storage. . . .

Purchase sufficient land for station, storage, and future increase ; and do not attempt to do what has been so often done, design a station to suit a lot—rather buy the lot to suit such a station as may be designed. Get near water if possible ; even if it is not at first intended to use condensing engines, it will eventually be done when increase comes if water can be obtained cheaply. The saving to be made in the handling of coal, and condensing even on a small power, will pay interest on quite a large capital for more than would be required in the majority of cases to attain good results. If coal has to be hauled, if only a short distance, it will cost from 40 cents to 50 cents a ton for haulage and handling ; it will rarely cost less than 40 cents. Suppose an average load to be 150 horse-power for street lighting, running, say, an average of ten hours per day all the year round—that is, for 3,650 hours per annum. If the average coal consumption were 4 pounds of coal per hour per horse-power (it averages more than this all over the country), 600 pounds of coal per hour would be required, or 2,190,000 pounds of coal—that is, 1,095 tons—which would cost for hauling at 40 cents per ton $438.00, six per cent. interest on $7,300·00. If water were used for condensing, twenty per cent. of fuel might be saved on 219 tons ; if fuel cost $4.00 per ton a sum of $876.00 might be credited to maintenance, or six per cent. on $14,600.00, in all $21,900.00, far more additional capital than would be necessary to expend to make the saving. The fact of condensing will increase the capacity of boilers, heaters, and pumps, or if desired a saving in expenditure would follow here, as well as an engine, which by condensing is also increased in power. At present it is not proposed to deal with the cost of construction, but rather to show what may be saved, which will amply repay for increased cost of construction, as will, it is trusted, be demonstrated later on, as well as leaving a margin for handsome dividends, and at the same time an opportunity for a reduction in rates which is so necessary to the attainment of a large general lighting business.

Whilst dealing with the matter of the location of a station, it must be borne in mind that the question of cost of copper for distribution and general line work must be considered. It will pay to expend some extra money in this direction to secure cheap handling of fuel, and reduction in its consumption ; but this may be carried too far, and the extent to which it is carried will depend upon cost of coal, amount of lighting, and many other details peculiar to the particular case under consideration.

Bad firing usually comes from the employment of cheap, and, therefore, inefficient help—another instance of parsimony in management. The majority of folks have an idea that any labourer taken off the streets will make a good fireman. So a great many of them will, but when they become so, they will seek other places unless paid in accordance with their skill. A saving of twenty-five or fifty cents a day in firemen's wages will result in a very much increased consumption of fuel. In some respects the fireman is more important than the engineer, for it is at the shovel probably that the largest savings in running expenses can be made. Listen and leave the constructing engineer alone when once a plan has been decided upon. Do not interfere with details or force poor material upon him, and the result will be a very much reduced cost of maintenance as compared with the average of electric light stations.

Taking a sample case, which is nearly similar to one that actually exists, it may be interesting to carry out the system outlined above, making estimates of cost of construction, running expenses, maintenance and income. The example to be considered is a case where the immediate amount of street lighting to be obtained amounts to 60 full arc lights (2,000 candle-power), running all night and every night with a certainty of at least 30 lights increase in twelve months, and in a territory requiring at least 360 street lights. In addition to this about 170 1,200 candle-power divided arcs will be used for commercial lighting.

A plant of 3,500 incandescent lamps capacity of 16 candle-power lights will be required immediately, with a prospect of very rapid increase, provided rates are suitable. Thirty-five horse-power of motors can be placed at once, with prospects of at least doubling that amount in twelve months with good management.

The conditions of commercial lighting are as follows : Stores close at 6 o'clock generally on four and five nights of the week, and at 10 and 11 o'clock on one or two nights, except during the holidays, when they close at 11 and sometimes 12 o'clock every night. A number of the stores keep their window lights running until 11 o'clock every night. There are a few halls and churches requiring occasional lighting, a considerable amount of incandescent lighting in basements and in stores on dark days, necessitating running during the twenty-four hours.

The majority of the lighting is in stores, some hotel lighting and some business lighting in banks and insurance offices, closing at 4 and 5 o'clock, while the prospect of house lighting is very good.

Summarising the dynamo capacity required for such a station, we find that the power required will be as follows :—

		H.-P.
60	Full arc lights (2,000 candle-power) for street lighting ..	60
170	Divided arc lights (1,200 candle-power) for commercial lighting	125
3,500	16 candle-power incandescent lamps	350
35	Horse-power motor capacity	35
	Total horse-power	570

Before determining the size of lot required it will be necessary to prepare a preliminary sketch of buildings, and to do this the capacities and number of the various dynamos and their arrangement must be settled, to provide sufficient space for them. The question of the subdivision of power has also to be considered, in order that the capacities and dimensions of engines may be arrived at before designing the engine room, and finally the amount of increase of business to be allowed for, in order that the dimensions of the various rooms and their combination in one building may be planned.

The units of power, which will be the most important element in economy, can be best determined by setting out graphically the variations in power during the 24 hours. These under the particular conditions assumed will be on Saturday in the winter, when the heaviest loads and those of longest duration are to be expected, and for which of course the work must be primarily arranged ; for the remaining days in the week the subdivisions of power will be the same, the duration of the heavy evening load being shorter, commencing to drop more rapidly at 6 o'clock and continuing to do so until 9 o'clock, when it drops more slowly again to the ordinary night load.

The accompanying curve has been very carefully laid out from the conditions assumed with the aid of over 12 months' records of a station working under similar conditions.

The vertical seal is the power seal in units of 100 horse-power, and the top horizontal scale represents time, in divisions of 2 hours. Commencing at 12 o'clock at night, the power required is uniform until the early morning, when the incandescent load begins to rise ; at six o'clock, when the motors are put on, there is a sudden rise in the curve ; a little later the street lamps are cut out, which causes another drop ; meantime the incandescent load is rising until the stores are opened, then there is a gradual decline until the load again becomes uniform until 12 o'clock noon, and the motors are stopped until one o'clock, as indicated by the curve line. After one o'clock the load is again uniform until towards dark, when the incandescent load begins to increase rapidly. The commercial arc lights are thrown into circuit and finally the street lights, and at six o'clock, when the maximum load has been attained, for a short time the motors are cut off, as indicated by the vertical drop in the curve, followed by a slight reduction in the incandescent load ; at

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about nine o'clock there is a perceptible reduction in the incandescent load, and the incandescent and commercial arc load begin to fall with increasing rapidity until 12 o'clock, by which time the night load reaches its normal position.

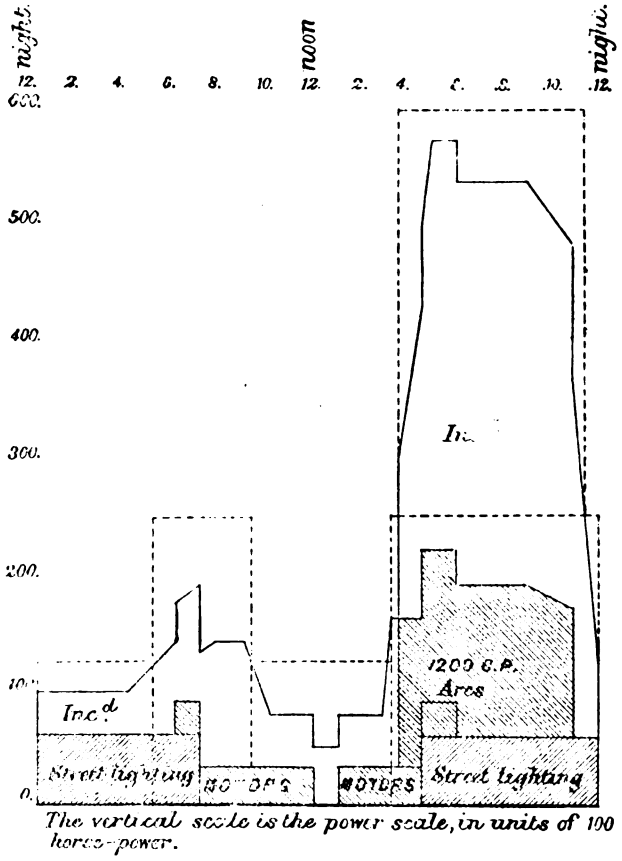
The portions of the total power used at any given time for 2,000 candle-power (street lights), 1,200 candle-power (commercial lights), motors and incandescent lights are all indicated on the curves, as will be readily understood when the diagram is examined.

The determination of the units of power into which the engines may be divided in order to keep any one, two, or three engines loaded within their economical range may now be determined, and is indicated by the dotted horizontal and vertical lines in the diagram, the horizontal lines obviously showing the duration of each load, and the vertical dotted lines the starting and stopping of each engine. It will readily be understood that such a division of power will require shafting and an arrangement of cut-off friction couplings, which will enable the changes in the engines to be made without shutting down dynamos, and also in order that the portions of shafting required at any time may be cut in or out. Proceeding at first on this assumption, we determine that engines of the following capacities are required, viz. :—

125 horse-power for night and normal day load.
250 horse-power for morning and first portion of afternoon and latter part of evening load.
350 horse-power for duration of heaviest load to be used in conjunction with the 250 horse-power engine.

725 total horse-power.

On Sundays and holidays the 125 horse-power engine and the 250 during the evening will suffice.



The vertical scale is the power scale, in units of 100 horse-power.

In the summer it will be found that except on Saturday evenings the 250 and 350 horse-power engines will rarely come into use together.

The arrangement of three such engines in an engine room would require a space of about 45ft. by 60ft., allowing for some increase in engine capacity by the removal of the 125 horse-power engine to be replaced by a 600 or 700 horse-power engine, which would allow for an increase about doubling the capacity of the plant.

A boiler room having an ultimate capacity of 1,300 horse-power, with, say, one additional boiler of 125 horse-power, would require a space of 45ft. by 100ft.

If the dynamos are placed above the shafting, a dynamo room, 34ft. by 75ft. or 80ft., would be ample for 1,300 horse-power of machines.

A building occupying about 100ft. by 80ft., with an extension for boiler room of 50ft. by 60ft., would probably suit.

A lot from 160ft. to 200ft. by 100ft. would be suitable.

The dynamos required are as follows :—

2 30 full arc lights (2,000 candle-power).
4 45 divided arc lights (1,200 candle-power).
1 80 horse-power motor generator
1 650 light incandescent alternating dynamo.
2 1,500 ,, ,, ,,
2 Exciting dynamos each of capacity capable of exciting the fields of all the alternating dynamos.

Preliminary estimates are necessary of the cost of such a plant, the amount of fuel required, assuming that the two large engines are compound condensing and the small engine a condenser ; and an estimate of the cost of maintenance and running expenses, to which being added a fair dividend, after estimating the number of horse-power-hours produced per annum, the rate per horse-power can be readily arrived at, and from it rates determined for each class of work, which will pay a sufficient profit to induce the investment of capital.

The cost of such a station would be, say, about as follows :—

Property	from $15,000 to $20,000
Buildings and foundations	20,000
Chimney	4,500
Arc dynamos and lamps	23,000
Incandescent dynamos and lamps	36,500
Motor generator motors and adjuncts	10,000
Mem. These items include station wiring and fitting.	
Engines and foundation including condensers, &c.	25,000
Boilers and settings, steam piping, pumps, injectors, feed-water heaters, &c.	20,000
Shafting, pulleys, clutches, &c.	4,000
Belting	4,000
Pole lines, pins, insulators, cross arms, wire and outside construction	50,000
Office and stone room fitting and sundries	1,000
Tools, &c.	1,000
Total	$229,000

Capitalise at, say, $230,000.

Proceeding now to estimate the cost of operating such a plant, primarily determine, as being most important, the labour required, and the total horse-power-hours developed in order to arrive at fuel consumption.

The superintendence and labour will be about as follows :—

	Per annum.
Superintendent and manager	$3,000.00
Assistant superintendent	1,200.00
Accountant	1,000.00
Office boy	250.00
Chief engineer	1,500.00
Two Assistants	1,800.00
Two dynamo attendants	1,800.00
Two Oilers	1,500.00
Three Firemen	2,100.00
One Labourer	730.00
Three Trimmers	2,190.00
One Lineman	780.00
One Incandescent Wireman	780.00
One Boy (to assist Wireman)	300.00
	$18,930.00

These salaries and wages may appear high to many, but we are assuming that all work is to be of the best, and all *employés* of a high class.

(To be continued.)

THE PHYSICAL SOCIETY.

Electrical Measurement.*

BY PROFS. AYRTON AND PERRY.

(Concluded from page 490.)

The Paper next described the experiments that had been made to determine the exact law of variation of the effect of a layer of wire in their ordinary magnifying spring instruments with the distance of the layer from the axis, and to determine the best thickness of winding to employ in one of their instruments, and the authors found that whereas a given deflection could be produced with the least expenditure of watts when the radial thickness of the winding was very small, the ratio of cooling surface to watts expended increased with the radius of the bobbin. Hence the later instruments being wound to a greater radial depth than the earlier

* Abstract of Paper read at the Physical Society, February 23rd.

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ones enabled a given deflection to be maintained with a less rise of temperature of the instrument. They next described how the experiments had led them to see that the permanent magnetism error of a given piece of iron when used in a measuring instrument, and which tended to make the readings for an ascending current less than for a descending current, could be diminished by altering the depth of the winding. The method that they had employed at the Acme Works of constructing a standard d'Arsonval instrument, which could be used to measure currents from a fraction of an ampere up to 600 amperes, and a P.D. up to 500 volts, such that the motion of the spot of light over the scale was never less than 4½in., even when the smallest current or P.D. was being measured, was referred to, and the difficulties they had met with in arranging a d'Arsonval instrument so that the deflection from one end of a three-foot scale to the other should be strictly proportional to the current, was described, as well as the method by which these difficulties had been overcome by their assistant, Mr. Bourne, by allowing the coil to hang freely from a torsional suspension above the coil, and arranging an extremely elastic non-directive suspension to lead out the current at the bottom.

Tests of the exact constancy of the ratio of current to square root of deflection of a Siemens dynamometer were then described, and it was shown that in consequence of a slight distortion of the spring in the dynamometer which occurs in all the dynamometers they had tried for a rotation of the milled head through even 180deg., the constant of the instrument was not really constant, but varied as shown below, a deflection of 400 divisions corresponding with one complete rotation of the torsion head.

Deflection.	Current. / √Deflection.
21·5	1·080
54·3	1·085
121·2	1·090
188·7	1·092
270·5	1·095
334·5	1·093
406	1·091

Prof. Ayrton, who gave an abstract of the Paper at the meeting, then referred to the modified Cardew voltmeter, devised by Prof. Perry and himself, and described in a Paper read before the Society of Telegraph-Engineers and Electricians at the end of 1887. He stated that the results of a long series of experiments had led to an important correction in the equations worked out in that Paper, and mentioned that by taking advantage of this correction they had been enabled to construct voltmeters to measure potential differences as low as one volt to within a hundredth of a volt, such as the instrument shown in the accompanying illustration, and which had been especially devised for measuring the alternate P.D. at the terminals of the secondary coil of a Thomson and Houston electric welder, which they found by experiment to be between one and two volts. It indicates up to 2·16 volts, which produce a rotation of the pointer through 360°. An instrument was also shown giving the same rotation for a potential difference of eight volts.

The extreme sensibility of this type of voltmeter was demonstrated by using it to measure the E.M.F. of an accumulator and the fall of the P.D. at its terminals when the accumulator was sending a current. The E.M.F. of the accumulator used was shown by the hot wire voltmeter to be 2·07 volts, and the P.D. fell to 2·03 volts when the current sent, as measured by one of their ordinary magnifying spring ammeters, was 10 amperes. Hence the resistance of the accumulator was

$$\frac{2\cdot07 - 2\cdot03}{10}, \text{ or } 0\cdot004 \text{ ohm.}$$

The error referred to in the investigation previously made was the neglect of the alteration of the length of the platinum-silver wire due to the alteration of stress as the sag of the wire varied,

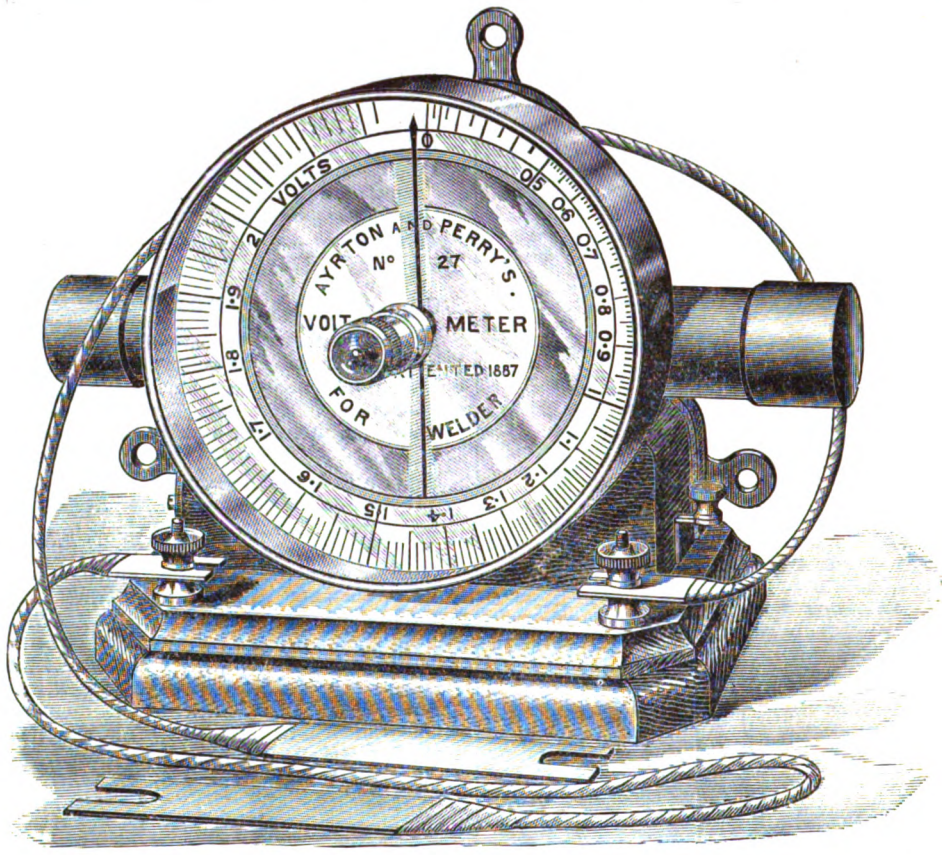

Fig. 1

for the authors believed that the stress in the wire was too small for the alteration of length due to the diminution of stress in the wire expanding to effect the alteration of sag produced by the application of a given P.D. They remarked that their having omitted to take into account this effect of the alteration of stress was the more curious since one of them pointed out in *The Electrician* in the autumn of 1887 the importance of not neglecting it in the case of the telegraph wires, and showed how the compensating action, thereby introduced, enabled the dip of a telegraph wire in summer to be made much less than would be possible without the wire breaking in the winter if the simple change of length of the wire by change of temperature were alone considered. In the early part of 1888, however, they found that the change of stress produced a sensible effect in diminishing the increase in length in the fine platinum-silver wire of their voltmeter which would otherwise be produced by the change in temperature. The result of a long series of experiments, which have since been confirmed by a complete mathematical investigation, showed that with a given magnifying spring the rotation of the pointer for a given P.D. applied at the terminals of a given wire varied, as shown by the following figure, No. 2, when different initial sags were given to the wire, and they

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found that with a particular wire, pulled with a particular magnifying spring having a certain definite initial tension, there is a certain initial sag for which the sensibility of the instrument is a maximum, and the authors have, therefore, endeavoured to adjust the initial sag of each instrument so as to give the maximum sensibility.

Another important effect of the alteration of stress with alteration in the sag is that the temperature coefficient of the tube to the ends of which the wire is attached depends on the initial sag. This is a decided advantage, as the tubes can be made of copper and iron in fixed proportions, and finally adjusted by adjusting the initial sag until no change in the zero position of the pointer, as well as no change in the deflection due to a given number of volts, is produced by warming the instrument as a whole, thus reducing the temperature error to a minimum.

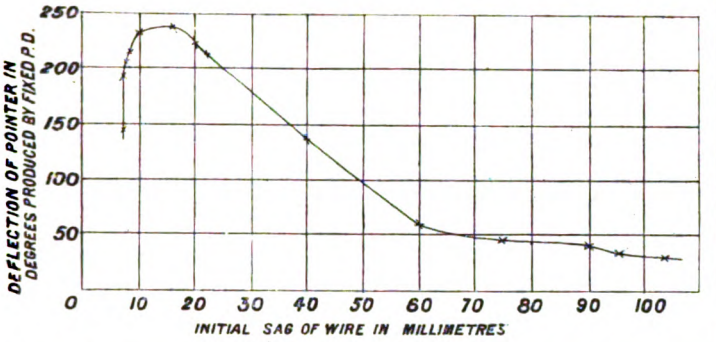

FIG. 2.—Experimental Hot-Wire Voltmeter. Length of Platinum Silver Wire, 208mm.

Fig. 3 shows a horizontal section of the instrument as at present constructed by the Acme Works. In the original instrument the pull of the magnifying spring M was counterbalanced by the pull of the platinum-silver wire W W attached to the blocks B B ; but, to save space, both these pulls on the present instrument act in the same direction, and are counterbalanced by the flat spring M. Hence, as the wire stretches the magnifying spring M is stretched, and the pointer P P, to which a number of fine hairs are attached to introduce damping without solid friction, rotates. The flat spring is not only introduced to enable the depth of the instrument to be diminished by twice the sag of the wire, but to enable a particular arrangement of force to be employed. In the ordinary Cardew instrument, with its two yards length of wire, the introduction of a short fuse which will melt with a current too small to damage the instrument does not seriously increase the resistance or diminish the sensibility, but in Profs. Ayrton and Perry's hot-wire voltmeter, which contains only 8in. of wire, the introduction of such a fuse would diminish the sensibility ;

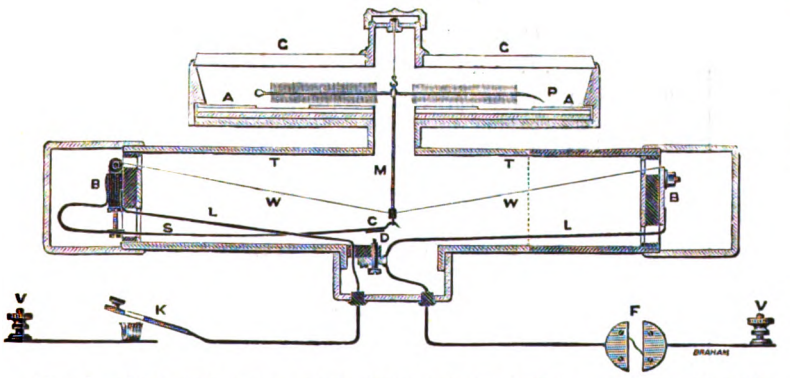

FIG. 3.—Horizontal section of the latest pattern Ayrton and Perry Hot-Wire Voltmeter.

and it is practically impossible to diminish the length of the fuse wire in proportion to the length of the working wire, as the conduction of heat by the metallic blocks, to which an extremely short length of wire is attached, prevents its quickly melting. Hence, they employ a fuse, F, of such a diameter that it would require a far larger current to melt it than would damage the instrument, and they arrange in addition a platinum-tipped screw, D, so that when the wire W W stretches by any prearranged percentage beyond the amount it stretches for the maximum safe P.D., the platinum tip C of the flat springs comes into contact with the screw D, and the working wire is short-circuited. The circuit is then temporarily completed through the lead L, to the left, the flat spring S and the fuse F, when the current increases and the fuse melts without damage to the instrument. With this device they find that the fuse may be thick, and, therefore, have but a small resistance compared with that of the working wire, and yet the sudden application of a P.D. five or six times as great as the maximum P.D. the voltmeter is intended to measure, melts the fuse without damaging the working wires. For clearness, the fuse, the key, and the terminals V, V are shown detached from the instrument, but they are in reality in the base, as seen in Fig. 1.

ON THE DESIGNING OF CONTINUOUS-CURRENT DYNAMO MACHINES.

BY PROF. JAMIESON, M.INST.C.E., F.R.S.E.

(Concluded from page 489.)

Proportioning of Ampere Turns between Shunt and Main Coils.—The total ampere turns have now to be divided in proper proportion between the series coils and the shunt coils of the field-magnet windings.

In order to do this, so as to give the desired form of characteristic curve, we must have recourse to actual experiment. The following method is carried out by Messrs. M'Whirter, Ferguson and Co., Faraday Works, Govan :—

1. A workshop bobbin or experimental coil, with a known number of turns of wire, is kept for every size of dynamo machine made. This bobbin is put on to the magnet core in circuit with an ampere-meter, and is separately excited by another dynamo or storage cells. The dynamo to be wound is run at the normal speed with the external circuit R_e, equal to that of shunt, viz., 77ω, and with the voltmeter placed between the terminals. The exciting current through the experimental bobbin is now gradually increased until the required number of volts is observed on the voltmeter. *E.g.*, suppose the experimental bobbin to have 500 turns, and the ampere-meter reads 8·25 amperes, when the normal voltage of 100 volts is reached, then the ampere turns of shunt wire

$$A \times T_{sw} = 500 \times 8{\cdot}25 = 4125 \text{ ampere-turns.}$$

2. Connect up the armature of the dynamo being constructed to a resistance equal to the joint resistance of the shunt and the normal lamp circuit through an ampere meter, and run the dynamo at the normal speed. Now increase the exciting current in the experimental bobbin until the normal voltage of 100 volts and normal armature current of 65·3 amperes are both obtained. At the same time observe the exciting current.

But, the total required ampere-turns = 6875, and from experiment (1) we found that 4,125 ampere-turns produced the requisite E.M.F.

$\therefore$ 6875 − 4125 = 2750 ampere-turns left for series coils.

3. The normal current at full load required to pass through the series coil was found to be 65·3 amperes.

Consequently the number of turns required in the series coils

$$= \frac{2750}{65{\cdot}3} = 42 \text{ (about).}$$

4. From experiment (1) we found that 4,125 ampere-turns gave us the required excitation to produce the normal E.M.F., and from our former calculation we found that the current in shunt,

$$\therefore \frac{4125}{1{\cdot}3} = 3173 \text{ turns.}$$

$$C_s = 1{\cdot}3 \text{ ampere.}$$

But the series coils are also carrying the 1·3 ampere required for the shunt when dynamo free.

$\therefore$ 3173 − (42 turns × 1·3 a) = 3173 − 54 = 3119 turns on shunt coils.

5. All we now have to do is to so proportion the size of our series and shunt coil conductors that they shall carry the necessary currents required in each case at the rate of not exceeding 1,000 amperes per square inch. For armatures this may be and is in practice increased to even 3,000 amperes per square inch without undue overheating, owing to the cooling effect of the air carrying off the heat generated in the revolving armature. Mere radiation only acts on the field-magnet coils ; therefore the sectional area is of necessity much greater.

Example 2.—Now take the case of a Rankin-Kennedy short-shunt compound dynamo. The particular dynamo in question was tested by the writer after completion with the following results :—

Resistance of armature, warm	R_a	= ·04 ohm.
Resistance of magnet shunt, warm	R_s	= 20 ohms.
Resistance of magnet main coil, warm.....	R_m	= ·03 ohm.
Current in working circuit.....	C_c	= 108·5 amperes.
Current in shunt-magnet coils	C_s	= 5 amperes.

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Difference of potential at dynamo terminals E_e = 100 volts.
Difference of potential at brushes ..... E_b = 103 volts.
E.M.F. generated in armature ..... E_a = 108 volts.
Turns of armature wire ..... T_{aw} = 180.
Number of armature revolutions per minute N_{ar} = 620.

Electrical Efficiencies.

External electrical power, or "output," available for electric lighting, &c. $= C_e \times E_e = 108{\cdot}5_a \times 100v = 10{,}850$ watts $= 88{\cdot}7\%$
Power absorbed by armature $= C_a^2 \times R_a = (113{\cdot}5)_a^2 \times {\cdot}04\omega =$ 515 watts $= 4{\cdot}2\%$
Power absorbed by shunt magnet coils $= C_s \times E_s = 5_a \times 103v =$ 515 watts $= 4{\cdot}2\%$
Power absorbed by main magnet coils $= C_m^2 \times R_m = (108{\cdot}5)_a^2 \times {\cdot}03\omega =$ 353 watts $= 2{\cdot}9\%$
Total e'ectrical power,
$(C_e \times E_e) + (C_a^2 \times R_a) + (C_s \times E_s) + (C_m^2 \times R_m) =$ 12,233 watts.

the only difference between this dynamo and our last example being that the magnet core was made of the best hammered scrap iron instead of cast iron, and consequently the permeability is greater. The constants to be used in the formula are therefore less, and we have to substitute 2 for 3, and 1,500 for 1,800 as found by experiment.

From the measured dimensions of the dynamo we found :—

$L_m = 38$ inches. $S_m = 98$ square inches.
$L_{as} = 0{\cdot}45$,, $S_{as} = 195$,,
$L_a = 15$,, $S_a = 46$,,

$$\therefore R_m = 2\frac{L_m}{S_m} = 2\frac{38}{98} = {\cdot}76,$$

$$R_{as} = 1500\,\frac{2\,L_{as}}{S_{as}} = 1500\,\frac{2\times{\cdot}45}{195} = 6{\cdot}9$$

$$R_a = \frac{L_a}{S_a} = \frac{15}{46} = {\cdot}33.$$

Total magnetic resistance = 7·99.

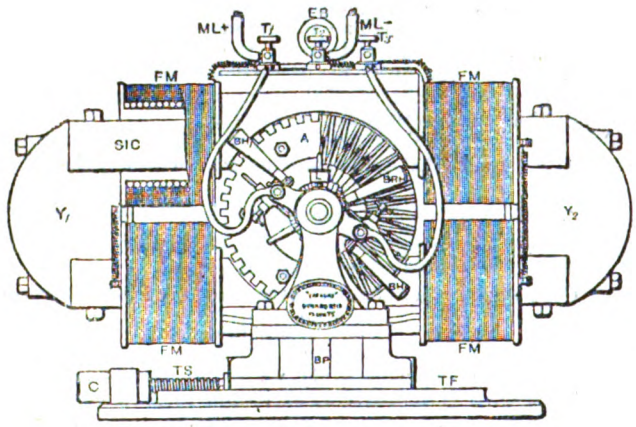

Fig 2.

B P, Bed Plate ; T F, Tightening Frame ; T S, Tightening Screw ; F M, Field Magnets ; Y_1 Y_2, Yokes (cast iron) ; S I C, Soft Iron Cores ; A, Armature ; B H_1 B H_2, Brush Handles ; M L+ M L−, Main Leads ; T_1 T_2 T_3, Terminals.

Now, by substituting in our former formula the actual values obtained for the E.M.F. in the armature, turns of armature wire, and revolutions per minute, we get the magnetic flux in Kapp lines flowing through the armature. Or,

$$K_{La} = \frac{E_a}{T_{aw} \times N \times 10^{-6}} = \frac{108}{180 \times 620 \times 10^{-6}}$$

= 968 *lines of magnetisation through armature, or at the rate of* 21 *Kapp lines per square inch.*

But in dynamos of this class it has been found that the number of magnetic lines passing through the armature are only 80 per cent. of the total magnetisation in the field-magnets. Consequently,

80% : 100% :: 968 : x

$\therefore x = 1210$ *Kapp lines through the magnet cores, or at the rate of* 12·3 ***Kapp lines per square inch.***

From our former formula,

$$K_L = \frac{A \times T_{mw}}{R_m + R_{as} + R_a}$$

$$1210 = \frac{A \times T_{mw}}{7{\cdot}99}$$

= 9668 ampere turns on the field-magnets.

The actual ampere turns were 9,800, or the calculation is only about 1 per cent. less than the *actual* amount required to satisfy the requirements of the installation.

Example 3.—Take the case of a Faraday compound dynamo, also tested by the writer, supplied by Messrs. M'Whirter, Ferguson and Co., Govan, to the Blair Lodge School, where (*see* Fig. 2)

$R_a = {\cdot}0315\,\omega$ $E_e = 100v$
$R_s = 31{\cdot}0\,\omega$ $E_a = 107{\cdot}6v$
$R_m = 0{\cdot}012\,\omega$ $E_b = 102v$
$C_e = 130{\cdot}0\,a$ $T_{aw} = 240$ (48 commutator bars)
$C_s = 3{\cdot}55\,a$ $N_{ar} = 800$

This dynamo being of the double horseshoe magnet type, and the cores being of the best Swedish iron, with large cast-iron yokes, we use a constant 2 for wrought-iron cores, and 1,440 for specific resistance of copper and air space due to wrought cores and pole-pieces.

From the actual dimensions of the dynamo we found :—

$L_m = 32{\cdot}0$ inches. $S_m = 33$ square inches (only 1 magnet core).
$L_{as} = 0{\cdot}5$,, $S_{as} = 54$,, ($\frac{1}{2}$ air space surface).
$L_a = 12{\cdot}0$,, $S_a = 15{\cdot}6$,, ($\frac{1}{2}$ section of armature).

$$\therefore R_m = 2\frac{L_m}{S_m} = 2\frac{32}{33} = 1{\cdot}94$$

$$R_{as} = 1440\frac{2\,L_{as}}{S_{as}} = 1440\,\frac{2\times{\cdot}5}{54} = 26{\cdot}6$$

$$R_a = {}^*2\frac{L_a}{S_a} = 2\frac{12}{15{\cdot}6} = 1{\cdot}54$$

Magnetic resistance of half-dynamo field = 30·08

Now,

$$K_{La} = \frac{E_a}{T_{aw} \times N_{ar} \times 10^{-6}} = \frac{107{\cdot}6}{240 \times 800 \times 10^{-}}$$

= 530 *lines of magnetisation through armature, or at the rate of* $\frac{530}{15{\cdot}6 \times 2} = 17$ *Kapp lines per square inch of armature section.*

Allowing, as before, that only 80 per cent. of the total magnetisation passes through the armature, we have

80% : 100% :: 530 : x.

$x = 662$ Kapp lines through both the magnet cores, or 331 lines through each half, which is at the rate of 10 Kapp lines per square inch of magnet core section.

$$\therefore K_L = \frac{A \times T_{mw}}{R_m + R_{as} + R_a},$$

Or $A \times T_{mw} = K_L\,(R_m + R_{as} + R_a$;

$\therefore A \times T_{mw} = 331 \times 2 \times 30{\cdot}08 = 19913.$

The actual ampere turns were 20,850, and the dynamo having a rising characteristic of 3 per cent., the calculation is only about 1·7 per cent. less than actually found by experiment.

LEGAL INTELLIGENCE.

In re Gaulard and Gibbs' Patent.

JUDGMENT.

COURT OF APPEAL.

(Before Lords Justices Cotton, Lindley and Lopes).

This appeal of Lucien Gaulard and others against a judgment pronounced by Mr. Justice Kekewich on July 9th, 1888, in the case of a petition for the revocation of certain letters patent which were granted to Messrs. Gaulard and Gibbs on the 13th September, 1882, came up for decision on Monday last.

LORD JUSTICE LINDLEY, in delivering the judgment of the Court, said this was an appeal from an order made by Mr. Justice Kekewich, by which he declared in substance that the patent claimed by Gaulard and Gibbs was invalid. That order was made under Section 26 of the present Patent Act, which had substituted a modern mode of procedure for the old one of *scire facias* to repeal letters patent. The objections taken to the present patent were the following :—First that, having regard to the previous state of

* 2 here is on account of the double field, or the magnetic lines or circuit entering from each side.

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knowledge, the patentees' invention was not one for which a patent could be obtained; secondly, that the complete specification was not for the same invention as that described in the provisional specification; thirdly, that the nature of the invention was not "particularly described and ascertained" by the complete specification; fourthly, that the complete specification had been so enlarged by amendment as to destroy the patent; fifthly, that the patented invention was not new. This last objection was so connected with the first as really to merge into it. In order to deal with these objections, the first thing to be done was to discover what the invention really was according to the patentees' own description of it. For this purpose the complete specification in its original shape ought to be studied in the first instance rather than the provisional specification, for the former document "particularly described and ascertained" the invention, whilst the latter only stated its general nature. If the provisional specification was studied in the first instance a general but loose and inaccurate idea of the real invention was likely to be obtained, and an incorrect conception might be thus formed, and if formed would probably lead to error. Turning, then, to the complete specification as it stood before it was amended, what was the invention really? The patentees claimed to have discovered a new system of distributing electricity for the production of light and power. The system consisted of a combination of the following particulars—first, an alternating current of high tension produced by an electro-dynamo machine; secondly, the passage of such a current through a number of electrical generators of a special construction; thirdly, the formation of such passage of induced currents, the quality and value of which depend only on the construction of the secondary coils of the electrical generators; fourthly, the utilisation of these induced currents for the production of light or motive power. The specification and drawings show that a main wire was to be used for the passage of the current produced by the electro-dynamo machine, that this main wire might be miles in length, and that the electrical generators were to be attached to this main wire where wanted. In the first instance, it was said that there might be an unlimited number of these generators. That expression has been amended and the word "unlimited" struck out. That amendment did not, in the opinion of their lordships, affect the validity of the patent. There might be as many electrical generators as in practice were wanted, and that was all that anyone would understand by the use of the word "unlimited" in connection with the rest of the specification. Having stated in general terms what the patentees' system or invention really was, it became necessary to ascertain what, according to the original specification, is the most essential element in it. That was the specially constructed electrical generators. It was impossible to read the complete specification as originally drawn without seeing that everything turned on those generators. The quality and value of the induced currents were said to depend only on the construction of the secondary coils, and they were specially claimed by the patentees in their third claim. It was also impossible to read the provisional specification without coming to the same conclusion. It was therefore necessary carefully to study these forms of generators. The electrical generators described in the specification and shown in the drawings were induction coils. But the patentees had described two forms of them—they did not say, and there was no reason to suppose it, that no other would do; nor did they point out what in particular was the essential feature of either of them—but the patentees had described two forms which had certain common features, and there was no reason to suppose that the forms described were not the best known to the patentees when they filed their specification. There was evidence that the forms described would produce the desired results, and there was no evidence to the contrary. Moreover, there was strong evidence that any competent workman could make induction coils which would produce the desired results by following the specification and drawings, and using such knowledge as he would himself possess. The patentees supposed a main wire fifty kilometres long, and a secondary generator (that is, induction coil) at every five hundred metres; but the size of the main wire was not stated. The first example of induction coil consisted first of a central coil of soft iron wire capable of being drawn out of or pushed into the hollow tube made by the wire coiled round it, and referred to generally. The word in the specification is "a wire" in the singular; but the Court understood that any competent workman or electrician would see that a bundle of wires, and not one wire, was meant, and the Court so read the specification. Secondly, it consisted of a copper wire of about 3mm. in diameter, perfectly insulated in three rows of super-posed coils round the core. This was the primary wire, and its length was not stated. A third element was the bobbins placed over the cylinder formed as above; and the fourth a cable wound round each of these bobbins, and composed of six copper wires of half a millimetre in diameter, each strand being insulated by means of paraffined cotton. This cable of six wires formed the secondary wire of the induction coil, and its length was not stated. The second example of an induction coil consisted, first, of a core like the above; secondly, of an insulated primary copper wire, four millimetres in diameter, surrounded by six cables, each composed of 12 insulated copper wires of half a millimetre in diameter. These cables formed the secondary wires, and were to be arranged parallel to and completely surrounding the primary wire, so as to form with it one cable. The proper lengths of the wires were not stated. The cable thus formed was rolled on a hollow cylinder of wood, say 50 centimetres long and six in diameter. Each layer of spirals was separated from the other by two cylindrical segments of iron, two millimetres thick and without contact, to avoid heating. The extremities of the six fine wire cables were united to a commutator, which allowed of their being moved either in tension or quality. It was apparent from those two descriptions that the patentees represent the cable formation of the secondary wires to be important, quite as important, in fact, as anything else they described; which, however, was admitted not to be the case. Having thus arrived at the nature of the invention and the mode of carrying it out, as described in the specification, let them now turn to the evidence given at the trial. Their lordships had studied the evidence with care, and had come to the following conclusions: First, although some of the specifications in earlier patents come very near to the patentees' invention, none of them quite come up to it. No one had previously hit on a combination of (1) an electrical dynamo machine producing alternating currents of high tension; (2) a long main wire; and (3) induction coils specially constructed placed along it at intervals for producing light and motion when required. The alleged anticipations all fall short of this. Their second conclusion was that the patentees' system was essentially the combination just mentioned, which was new and useful, and apart from the special construction of the induction coils; the system was indicated, as Sir William Thomson said, in the drawings to the provisional specification without the letter press. Thirdly, nothing really turned on the special construction of the secondary generators, on which the patentees unfortunately laid so much stress; they were not types of any class which had not all their special features. Fourthly, they considered that a competent person, having once seized the idea of the combination shown in the drawings, would see at once how to carry it into effect, and would without difficulty or further instruction select an induction coil suitable for his purpose without adopting either of the specially constructed coils, and without being told by the specification the lengths of the wires to be used, or the ratio which one of them must bear to the other in length, size, or weight. That, in the opinion of their lordships, was the true result of the evidence. Any competent electrician would see that a long main wire must, for economical reasons, be as small as circumstances would allow, that the tension of the current sent along such a wire must be high—far too high to bring into a lamp with safety—that this tension must be reduced, that induction coils could be made to reduce it, that the lengths and thicknesses of the wires would depend on the object to be attained, and could be ascertained from the law of tension—a formulæ given in Clerk Maxwell's book. The evidence, in their lorship's opinion, proved all that, and the state of knowledge was such as to supply the absence of instruction in the specification with reference to these details. The nature of the invention was "particularly described and ascertained," and two modes of carrying it into effect were sufficiently described to enable any competent electrician who seized the idea to give effect to it notwithstanding the want of detailed instructions. It was not necessary for the Court to decide whether the patentees could or could not have obtained a valid patent for their system apart from their specially constructed induction coils. Perhaps they might have done so. Unfortunately, that was not their intention as originally described. They have over-estimated the value of their specially-constructed generators, and have so drawn and altered their specifications as to have missed their mark. As already stated, their special form of generator was originally made an essential feature in their system. This was a grievous mistake. They have tried to correct it by amending their complete specification, but in doing so they have entirely changed their patent and the nature of their claim. To understand the effect of this amendment it is necessary to see what the patentees have done, and what they now claim by their amended specification to be the invention for which they have obtained their patent. The amended specification was vague and ambiguous on this very important point. If confined to a combination of dynamos giving alternate currents of high tension, with a main wire and one or two induction coils specially described, the patent will be of little or no use to the patentees; whereas, if construed more extensively, so as to include a combination of such a dynamo with any induction coil having the properties of the two described the patent would be of immense practical value, for the evidence showed that any coil which anyone would be likely to make would have such properties. The second of these two constructions was therefore obviously that which would be most beneficial to the patentees, and that was the construction which the patentees had laboured to maintain. The whole of their evidence was addressed to that. No serious attempt was made to show that there was any merit in the two specially described generators, except their movable iron wire cores, which almost all induction coils had in 1882. Their lordships were satisfied that no other construction was worth contending for, and it was, in their opinion, the true construction of the specification as amended. The specially-constructed generators were no longer claimed either separately or as essential parts of the combination; they were seen to have no particular value, and had been dropped accordingly. But this construction of the amended specification rendered the patent hopelessly bad in law, for (1) on this construction the invention is not the same as that described in the provisional specification, but an entirely different invention, and (2) on this construction the amendment of the complete specification has greatly extended the scope of the patent. As already shown, the essence of the invention, as described in the complete specification in its original shape and as set out in the provisional specification, lay in the use of a specially constructed electrical generator or combination which the patentees believed to be superior to all others, and, in fact, to have magical powers, and if they threw this over they so far departed from their invention as originally described as to render the patent they had obtained for it worthless and incapable of being supported. The law upon this point was perfectly well settled, and it was needless to refer to the authorities upon it. This view of the case rendered it unnecessary to consider whether the patent could be supported if it were construed narrowly and confined to a combination of an alternating dynamo with induction coils constructed like one of the two described in the specification. That point was not much argued. A decision in favour of the patentees would be of little use to them, and the patentees did not care which way it was decided, as they said they did not use that particular combination. That point, if it arose, would be full of difficulty, considering the evidence given at the trial; but having regard to the terms of the specification and the real contest between the parties, the Court did not think it called for decision. In their lordships' opinion the patent was bad, and the appeal must be dismissed with costs.

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *February* 23*rd*, 1889.

During the past fortnight the interest in electrical matters in this country has centred largely in the West. The Edison people, as I noted last week, have just held a highly successful Convention at Kansas City, and now the National Electric Light Association has been in Convention at Chicago. Both Conventions have been remarkably well attended, and have been like their predecessors in starting a hearty local interest in electrical matters. Kansas City, as one of the gateways of the South-West, was well chosen for the Edison Convention, and the gathering appears to have attracted a great deal of attention from the press in that section. If it did nothing else, the meeting served to advertise the new Edison plant in Kansas City, which is now nearly ready to go into operation, and which is reported to be one of the very best of the many fine Edison plants that have lately been installed. At Chicago special interest attaches to the Convention from the fact that the National Electric Light Association came into existence in that city four or five years ago in a very unpretentious fashion, and now revisits the scene of its birth a strong and influential body, full of life and vigour, and one that is capable, with judicious management, of doing incalculable good for the electric light and power industry in this country. It often happens that the two Conventions are held within a short time of each other, and sometimes in the same place. Thus we have the Chicago meeting following that of Kansas City, and it is said that both bodies will go to Niagara Falls next summer. But in spite of this there does not appear to be any material approach to an *entente cordiale* between the two organisations, although there are several electric light men who have probably membership in common, or could secure it if they wished. There can be no doubt that in some respects the Edison method of simply calling together those who are interested in the Edison light, and sitting with closed doors, has its advantages over the other method of bringing together a number of men representing conflicting interests, and often connected with rival plants in the same town, so that of necessity really vital questions are often avoided rather than discussed on the floor of the meeting. Moreover, the Edison Convention has the advantage in being composed of men who are actively engaged in the actual work of lighting, while on the other hand the National Association is largely composed of manufacturers of apparatus and dealers in supplies, so that matters are more apt to be viewed from their standpoint than from that of the man who has to produce current and sell it profitably for light and power. But putting these considerations aside, the National Association has achieved its success on the very ground that it is liberal and comprehensive of all electric lighting systems, as well as of all those in any way interested in their development, and its very catholicity of spirit in this respect has been one of the chief agencies in its growth and popularity.

As I have said, electrical interests in the West will undoubtedly be benefited by these methods of concentrating the public attention on them for a week or two. It is impossible for the daily papers in any community to give up their columns day after day to the discussion of the growth of electricity without arousing healthy and fruitful interest in the subject. The West, too, has always been particularly favourable ground for the reception of electrical ideas and novelties. In many towns and cities of the West practically the whole dependence for lighting has been on electrical apparatus, and in many others the current is largely used for power purposes as well. Some large isolated plants are also to be found in the West, and extremely good results are obtained with them. An example of what is done in this respect is furnished by the *Electrical World* this week, which published detailed descriptions and illustrations of the new Edison plant for 80,000 lamps in Chicago, and the fine new Thomson-Houston plant put in at St. Paul, Minn., for the local gas company. The *World* also contains another example in its article on the magnificent isolated plant of arc and incandescent lights in the big Pillsbury Flour Mills at Minneapolis. Some idea of the extent of these mills may be formed from the fact that one of them alone makes more flour than will feed New York and Brooklyn, and that the three together require 200 cars a day to bring the wheat to them and to take away the flour and refuse. The mills are driven by the water-power of the falls of St. Anthony, but have engines to fall back on in case the 135,000 horse-power there available should be overdrawn at any time by the numerous mills. The lighting plant includes Weston, Brush and Edison apparatus, and it is interesting to note that the current is used not only for lighting but for a number of other purposes. For example, there are 12 to 15 millwrights at work all the time, and they are provided with lamps and flexible cord connections to be inserted in the nearest lamp socket, so that light is available at any point. The lamps are used in the same way by the bolters to examine the bolting cloth, and by means of an ingenious little electric "furnace" the current is used in testing the quality of the flour. The ovens are heated by electricity, and the dougher, when he wants the ovens warm, just turns a switch throwing the current on, and in a few minutes the temperature is exactly what he wants, and is under perfect control. The current is also used to ring all the call bells at a saving of about £6 a month in battery material, and it operates fire alarm and other miscellaneous circuits. All that is needed to complete these ingenious utilisations of the current is that the heavy shafting that now requires so much attention and labour should be replaced by wires furnishing current to electric motors; and from the success already obtained in such work I believe it will not be long before these huge mills, as well as many others like them, will be driven by electric power.

Some idea of the popular curiosity and interest with regard to electric railways may be formed from the fact that the Boston *Herald*, in a recent Sunday edition, published the portraits of a large numbers of the drivers, or "motorneers," or whatever they may choose to call them, on the West End electric road in Boston. The paper also gives an interesting description of a trip taken by its reporter alongside one of these men, and of the various novel episodes that attended the journey to and from the car stables. Interviews with these men bring out the fact that they all prefer electric power very much to the old method of operating with horses. Not only is the Electric Motor Company a commercial society for the prevention of cruelty to brute beasts, but it appears to be equally humane in its work on behalf of the drivers. These men have no longer to stand in front of the car subjected to a hoof bombardment, with incessant jerks pulling their arms out, but can take things as quietly almost as if they were mere passengers. As one of them says, "It is out of sight and round the corner ahead of the old style. It is child's play compared with handling horses. Here you see I have over seven horses at my command. All that I need do to hitch them on or turn them off is to turn this pointer to or away from me. Each of these raised bars indicates a horse-power except the first, which stands for one and a-half. That small power is sufficient for a good pace on the level, and if we stop on the curve it will carry us around easily. In coming up a steep incline or a long hill we put on more power. This is in every way ahead of horses. The current is more manageable; we can stop quicker and start easier; no backing horses, no tired and played out nags to urge up hill on a sultry dog day. We can reverse our motion by simply turning the pointer; in fact, I could not conceive of anything more powerful, more tractable, and more easily managed than the electric current. I have driven horses for twenty-five years and know something about the work. I would not go back to driving horses again for anything." Such testimony as this from the men themselves speaks volumes for the advance that has been made by electricity in the development of urban transportation facilities, and I need hardly say that the public are just as enthusiastic as the drivers. What the company thinks of the results may be inferred from the reports which reach us of the intention to equip in and around Boston as soon as possible over 200 miles of the electric overhead system. How does that strike you for development, and not in a new Western town but in a Conser

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vative old place like Boston, which has as many obstructives among its population as any city of its size in Europe?

It appears by the reports from Boston that the market value of Bell Telephone Stock has advanced there this week owing to a report that the Patent Office has just taken action with regard to an application made by Mr. Emile Berliner, of Washington, relating to improvements in the telephone transmitter, and that the application in question will have the practical effect of extending the Bell monopoly, which would otherwise expire in four or five years It is alleged that this application is the one that was made by Mr. Berliner as far back as April, 1877, and that its issue has been delayed by collusive proceedings until now, an interference with Edison being utilised for the purpose, both applications being owned by the Bell Company. There has been talk from time to time in the past as to the pendency of this application, and the newspapers now take the matter up as illustrative of the means used to prolong profitable monopolies by a skilful manipulation of Patent Office methods. It has before been brought to the attention of the public by the Patent Commissioners that applications have been in the office nine or ten years in which the Patent Office was powerless to compel speedier or earlier action on the part of applicants, and it is claimed that this is one of such instances. Probably we shall soon know a little more about this. There is no doubt as to the favourable action on the patent by the Board of Examiners, but it is denied by the Bell Company that it is a bottom patent to be used for any such purpose as that which is now being subjected to denunciatory rhetoric on the part of the newspapers.

The American Institute of Electrical Engineers had an interesting meeting last week, when two valuable Papers were presented. One was by Lieut. F. J. Patten, U.S.A., on his new system of multiplex telegraphy, in which he employs as synchronous devices machines which are in themselves not isochronous, and the action of which is entirely dependent one upon the other. Hence the system differs materially from others in which synchronism is sought to be obtained by maintaining two mechanisms in unison by correcting any difference that might occur in their normal rates of independent operation. Lieut. Patten has devised a quantity of ingenious appliances for his purpose, and spoke in his Paper of his work for not only in connection with utilising the alternating current his purpose, but in employing a machine the armature which has two coils in series connection, but wound with their poles at right angles to each other. This armature being placed in a single field he had supposed would move at only half the speed of the first machine with a single armature; but, on the contrary, the synchronism was perfect, the motion was continuous in direction, and it has never been known to reverse. I need not, and, in fact, could not, go into the many details of Lieut. Patten's complicated and highly ingenious system, but I may say it was very favourably received, and in these days of machine telegraphy it seems likely to meet with a cordial reception on the part of the economising companies. The other Paper presented was one in discussion of Mr. Acheson's recent interesting Paper on lightning arresters, and the photographic study of self-induction, by Mr. J. Stanford Brown and Mr. T. C. Child, tending to throw a little doubt on the results which were arrived at by Mr. Acheson with so much care and painstaking.

NOTES FROM GERMANY.

(FROM OUR CORRESPONDENT.)

BERLIN, *Feb.* 25, 1889.

In Nuremberg the railway station, a *chef d'œuvre* of Gothic architecture, has been provided with the electric light. The passenger hall and platforms are lighted up by thirty 5-ampere lamps and four lamps of 10 amperes each, in addition to which the square before the station, the engine rooms, track ways, store houses and loading tracks, and the road along the goods platform, have been taken into the electric light area. The three dynamos used give 200 amperes at 120 volts, and are driven by three 32 horse-power non-condensing engines. The steam is furnished by two boilers on the Sinclair system of 59·5 square metres heating surface each. The insulation resistance of the installation was found to be 35,000 ohms, which corresponds to 120,000 $\frac{E}{C}$. This high value has its ground in the almost exclusive use of arc lamps. As to insulation resistance Prof. Waltenhofen, of Vienna, wants to read 10,000 $\frac{E}{C}$, whilst the *Elektrotechnischer Verein* of this town accepted the formula 5,000 $\frac{E}{C}$. Mr. Uppenborn gives his opinion in the *Centralblatt für Elektrotechnik*, and it is the same as Waltenhofen's.

For the town of Elberfeld two central stations have been planned, the district being a very long one. The northern station has been erected, and is working 4,300 lamps. The boiler house contains three boilers, with space for three more. There are four compound engines of 170 horse-power, each driving two dynamos with an output of 390 amperes at 121 volts. Twenty cables run from the station to the different quarters of the town, the three-wire system being used. The estimate for 10,000 lamps was 750,000 marks, of which sum so far 500,000 marks are spent.

The left side of the Main at Frankfort will be within a week or two provided with a small transformer plant. The complete plant was some weeks ago shown to the members of Ingenieur Verein of Cologne in full work at the works of the Helios Company. The result of these trials shows that, contrary to Prof. Rühlmann's assertion, properly-built alternating-current dynamos may be coupled in parallel by simple manipulation, and that it is possible to use alternating currents for the purposes of electrical transmission of power.

Messrs. Fritsche and Pischon's new wheel armature dynamo is said to be a great advance in the construction of dynamos. The new dynamo is a variety of the multipolar disc machine, in which, by a peculiar coupling of single rods, the winding of the armature is solely limited to the convex surface without using the plane faces. The armature is built up without a core, without cotton insulation, without copper, and without a special collector construction. It is built up of a lattice-work of wrought iron rods, which are separated by air spaces. The special winding does away with a complicated collector, the rods of the winding being prolonged as segments of the commutator. The smallest of these dynamos supplies 50 16 candle-power lamps, yielding 50 amperes and 65 volts at 240 revolutions per minute, or supplies 55 lamps and gives 25 amperes and 110 volts at 270 revolutions. The largest of them gives 3,200 amperes and 65 volts, or 7,600 amperes and 110 volts at 70 and 82 revolutions per minute respectively. These dynamos, therefore, supply 3,500 65-volt lamps, or 3,200 110-volt lamps.

Herr Zöpke, of Berlin, states that in the course of his business he has heard very different opinions about the Edison lamps sold by him. Some of his customers could not sufficiently praise the durability of the lamps, while others assert that the average life of a lamp is no more than a few hundred hours. It is well known that if the E.M.F. at the terminals is 100 volts, 95-volt lamps that burn 10 hours, 100-volt lamps that burn 100 hours, and 105-volt lamps that burn 250 hours, show the same amount of carbon deposit—that is, show the same blackening of their glasses. Besides, the 95-volt lamps show a brownish shine, originating from a small deposit of copper. From these deposits conclusions may be drawn as to the wear of these lamps, and if a rapid consumption is observed, an inspection of the whole plant, and especially of the voltmeter, is urgently necessary. Herr Zöpke therefore offers a prize of 1,000 marks, to be awarded by the Berlin Technical High School, for the solution of the following problems:—(1) Construct a constant voltmeter, not depending upon changes in temperature or structure of material; or, if this is impossible (2), construct a recording apparatus, as simple as possible, to control the voltmeter, which shall exactly register the time during which a too high voltage has been used.

CORRESPONDENCE.

THE PERIODICITY OF EARTH-CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps the following remarks may be of interest to your readers:—

On the Batavia-Singapore cable running N.W. and S.E., the diurnal earth-currents passing through it are very slight; and as I have been present at every one of the thirty-nine tests I quote, I have been able to make some rather interesting observations of the *annual* earth-currents, of the existence of which I was previously unaware.

When testing the copper resistance of a cable with the Wheatstone Bridge, always bearing in mind the fact that when there is a slight fault in a cable (which has been the case with ours since 30th August, 1887) the copper readings tend to be higher than the zinc, a little thought will verify the rule that

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when the zinc readings are higher than the copper a negative current is flowing from the cable, and when the copper readings are higher than the zinc the opposite is the case.

Hence, the direction of the earth-current can always be observed from the zinc and copper readings when testing the copper resistance if the cable is nearly perfect. When the cable is faulty, and the zinc readings exceed the copper, we are still sure a negative current is flowing from the cable. The following readings show that the earth-currents between Singapore and Batavia run for about six months in one direction, and then for six months in an opposite direction. Can they depend on the vernal and autumnal equinoxes?

Batavia-Singapore Section.

COPPER RESISTANCE.

Date.	Zinc.	Copper.	Independently Observed Earth-Current.
1887.	Ohms.	Ohms.	
April 20	6,208	7,692	
May 17	5,908	6,721	
June 6	5,164	7,800	
July 7	5,954	7,197	
„ 18	6,320	6,603	
Aug. 1	5,619	7,024	
„ 15	5,328	7,726	
„ 30	6,567	6,723	
Sept. 12	5,180	7,774	
„ 27	7,449	5,300	
Oct. 10	7,450	5,414	
„ 24	6,563	5,728	
Nov. 7	6,816	5,726	
„ 22	5,792	5,508	Positive ·5 of 1 minotto.
Dec. 2	7,607	4,618	
„ 19	6,461	5,819	„ ·002 „
1888.			
Jan. 3	Not taken.	Not taken.	Negative ·13 „
„ 16	6,120	4,579	„ ·5 „
Feb. 6	6,186	5,911	„ ·1 „
„ 20	6,401	5,734	„ ·07 „
March 5	6,381	5,664	„ ·03 „
„ 19	6,167	5,733	„ ·18 „
April 2	5,410	6,042	„ ·02 „
„ 16	6,605	5,655	Variable.
May 1	5,353	7,249	Positive ·29 „
„ 14	6,367	5,945	„ ·01 „
„ 28	3,855	4,767	„ ·02 „
June 12	5,022	5,323	Negative ·06 „
„ 25	4,851	6,575	Positive ·1 „
July 9	4,583	5,667	„ ·03 „
Aug. 6	5,205	5,305	„ ·02 „
„ 20	(*A*)	...	
Sept. 10	5,386	6,249	„ ·001 „
„ 23	5,015	6,585	„ ·3 „
Oct. 8	5,106	6,392	„ ·007 „
„ 22	8,325	4,424	Negative ·02 „
Nov. 5	9,954	3,820	„ ·2 „
„ 19	(*A*)	...	„ ·01 „
Dec. 3	8,256	3,885	„ ·02 „

(*A*) Tested with false zero.

N.B.—A slight fault was discovered in the cable on August 30th, 1887, which has not yet developed itself sufficiently to be localised.

On the 22nd November, 1887, the 19th December, 1887, and the 14th May, 1888, the earth-currents, when measured independently, were of opposite name to what, from the copper resistance readings, one would have expected them to be. I cannot understand this. Perhaps there was some mistake.—Yours, &c.,

A. H. BENGOUGH.

The Eastern Extension Telegraph Co.,
Batavia, 19th December, 1888.

THE INSULATION RESISTANCE OF INSTALLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think that Prof. Jamieson was rather unnecessarily severe in his remarks contained in *The Electrician* of the 22nd inst. on Dr. Waltenhofen's tests of the new Burg Theatre Installation. The Uppenborn method may possibly be old, but I cannot remember to have seen it described in any English Paper before what is practically a similar method was described in the article of M. Picou, which appeared in the *Electrical Review*, November 23rd, 1888. Certainly Dr. Waltenhofen first became acquainted with this method through Uppenborn's *Centralblatt für Elektrotechnik*, No. 22, of the year 1888, and this source only; he therefore was, I think, justified in speaking of it as he did.

At the meeting of the Committee of the Vienna "Electrotechnischer Verein," appointed to frame fire risk rules, Mr. Ross never claimed that the formula proposed by him was original. He stated clearly that he remembered to have read that a somewhat similar formula had been suggested, but could not say where he had seen it. It is not therefore surprising that this formula is locally called the "Ross" formula, and this has been rendered literally in translating Dr. Waltenhofen's Paper.

I am very glad that Prof. Jamieson appreciates generally the methods Dr. Waltenhofen adopted, and he cannot be otherwise than satisfied with the results obtained. The final measurements were not made after lamps, motors, &c. (please what does this "&c." mean?) were removed, as allowed by the rules of the Society of Telegraph-Engineers, but with *all* lamps, holders, switches, fuses, &c., connected. The *whole* installation was first lighted up and inspected, then the accumulators were disconnected as quickly as possible, and the measurements made at once.

Prof. Jamieson would not either have considered the amount of trouble and detail superfluous had he been acquainted with the whole circumstances of the case. I cannot, however, occupy your valuable space with going into them fully here, but shall be pleased to give Prof. Jamieson such privately if they are of interest to him.—Yours, &c.

T. W. W. MELHUISH, Assoc. M. Inst. C.E.

1, Schenkenstrasse 10, Vienna, February 28, 1889.

ENAMEL AS AN INSULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have recently made an invention which I consider of the greatest value to the electrical trade, and I shall be glad to publicly give them the benefit of my invention.

I find that such articles as the cores of electro-magnets, bobbins, and, I believe, even wire, can be coated with enamel or similar vitreous substance, and that this acts as a splendid insulator and protection for the wire to be wound thereon. It can also be used for the inside coating of iron tubes for the carrying of underground wires, and I think that many of your readers will find this of the greatest value.—Yours, &c.,

London, S.W., 2nd March, 1889. F. H.

GLOBULAR LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

[Translation.]

SIR: In spite of Mr. Sydney Evershed's jokes I can assure him that some fifteen years ago I saw a kind of fireball drop from some clouds which were very near to the ground, there being at the time a storm, accompanied by heavy rain. I say a kind of fireball because there was all around me brilliant red light. It fell in a corn-field, and seemed to crush the wheat as it slowly rolled along. All this lasted about a second; a violent explosion then ensued, and the fireball disappeared, without any other zig-zag lightning. Having at that time of my life but vaguely heard of globular lightning I could not believe my eyes; nevertheless, I did actually see the phenomenon.—Yours, &c.,

J. VAN MOORSEL.

106, Boulevard du Midi, Brussels.

ELECTRIC LIGHTING COMPANIES AT KENSINGTON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have perused Mr. R. S. Erskine's letter in your last issue, and I regret to hear that he considers that his company is likely to suffer from there being two electric light stations in Kensington—viz., that of his company, known as the "Kensington Court," and that of my company, known as the "Kensington Central."

I take the opportunity of pointing out to you the following considerations which bear upon this question:—

1. The Vestry of Kensington has mapped out the parish of Kensington, and very carefully allocated certain districts to

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certain companies, so that it is impossible for my company to carry its mains into the district served by the Kensington Court Company, and it is equally impossible for the Kensington Court Company to bring its mains into the district allotted to us; so that I cannot see where confusion can arise.

2. In the event of customers in the Kensington Court district applying to us it is clearly out of our power to supply them, and all we can do is to refer them to Mr. Erskine's company; and if he adopts the same procedure with customers applying to his company for light in our district we can mutually work Kensington without trespassing upon one another's business.

3. Mr. Erskine points out that the Board of Trade have not yet sanctioned the license which is before them in favour of our company, and then he complains that we have up to the present time done no lighting in Kensington. No one is better aware than he is himself that until the Board of Trade's sanction is obtained no extensive lighting can be done, and that in the meantime we are limited to supplying the streets belonging to private persons where we have laid the mains without having to apply to the Board of Trade for its consent.

4. Mr. Erskine again draws attention to the fact that my company claims to have erected "the first station which has been completed in the metropolis for the accomplishment of house-to-house electric lighting throughout an extended area by means of underground mains." My managing director, Mr. Robert Hammond, has pointed out to Mr. Erskine, in the *Times* and elsewhere, that Mr. Erskine's intimation that his company has done satisfactory work over a small area by means of underground mains is no refutation of the claim made by the House-to-House Electric Light Supply Company (Limited) that its station at Kensington is the first station completed in the metropolis designed to cope with electric lighting over an *extended area* by means of *underground mains*. The fact that Mr. Erskine's company has laid down a second station at Knightsbridge within a short distance of the first station proves that from the first station his company is not able to cope with an extended area.

5. Mr. Erskine is well aware by what authority my company is supplying a portion of Kensington, and he is also well aware that the Vestry have sanctioned the application of my company to the Board of Trade for a Provisional Order covering a much more extended area than the one we are at present dealing with.

6. The station of my company has been called the Kensington Central Station, because it has been erected within the parish of Kensington, and is designed to supply a considerable portion of that parish with the electric light, and though we started by calling it the West Brompton Station, we found that name did not sufficiently appeal to the householders of Kensington, to whom we were offering the light.

Apologising for the space taken up by this letter, I am,
Yours, &c., H. St. John Winkworth,
Secretary The House-to-House Electric Light Supply Company (Limited),

117, Bishopsgate-street Within, London, March 5th, 1889.

[As we are unable to see what useful purpose is served by a correspondence of this nature, we must beg that it now cease. —Ed. *E.*]

COMPANIES' MEETINGS & REPORTS.

Brighton and Hove Electric Light Company.

The annual meeting of the Brighton and Hove Electric Light Company (Limited) was held last week. The report was printed in our last issue.

In the absence of the Chairman of the Company (Mr. Robert Hammond), Mr. PHILIP ARDERNE LATHAM, one of the Directors, took the chair. He said he had much pleasure in laying before the shareholders such a satisfactory report and balance-sheet, showing that, after debiting the revenue account with the necessary outlays for keeping the plant in thorough repair, the Directors were able to write off 5 per cent. for depreciation of plant and pay a dividend of 5 per cent., which dividend would have been much larger if the Directors had not decided during the past year to run the machinery day and night, in deference to a very generally expressed wish on the part of the customers. The new plant has given very great satisfaction to the consumers, who were able in private houses to turn on the light at any hour of the night or early morning, and thereby found it a great convenience. It, however, kept the works in operation during the whole of the twenty-four hours, and entailed a great increase in wages and other charges, and he considered that it was a matter of great congratulation that in spite of these extra charges the 5 per cent. dividend which was declared twelve months ago had been maintained for another year. During the past year the Board of Trade's electrical adviser had visited Brighton and inspected the installation, and in consequence the Company had received from the Board of Trade a request that the Company should, without delay, apply for Parliamentary powers. In accordance with this intimation the Company had applied for Parliamentary powers, but he was sorry to say up to the present time this application had not received favour from either the Brighton Corporation or the Hove Commission. He considered this a great pity, because the Company would prefer to work harmoniously with the Brighton Corporation and the Hove Commission, instead of obtaining powers over their heads; for he would point out that the Electric Lighting Act gave to the Board of Trade power of granting a Provisional Order in spite of the opposition of a Corporation in cases where they considered that the opposition was of an immaterial character. He was, however, in hopes that a *modus operandi* could be arranged by which the Company could work in friendly accord with both the local bodies. Their one desire in applying for statutory powers was to abolish the overhead wire system and run mains underground, but the shareholders would understand that it was impossible to do so without obtaining Parliamentary powers. As soon as the mains were run underground the Company would be enabled to greatly improve its service by putting in larger mains and getting a better regulation of the light. The shareholders of the Company had recently met and sanctioned the raising of the nominal capital of the Company from £25,000 to £100,000, and the change of the name from the Brighton Electric Light Company, Limited, to the Brighton and Hove Electric Light Company (Limited). When the Parliamentary powers had been obtained, the shareholders would be called together and consulted with regard to further plans for the extension of the Company's operations. He might mention, too, that the Directors had in contemplation the immediate erection of a central station on the confines of Hove with a plant sufficient to supply 12,000 incandescent lamps somewhat upon the scale of the station which had recently been erected by a kindred company in London. He had much pleasure in moving that the report of the Directors and the accounts for the year ended December 30th, 1888, be received.

This resolution was seconded by Mr. ARTHUR WRIGHT, and carried unanimously.

It was then proposed and carried unanimously that the retiring Directors, Mr. Robert Hammond (the Chairman of the Company) and Mr. Arthur Wright, Managing Director, should be re-elected.

The CHAIRMAN then moved that the Auditors of the Company for the ensuing year should be Messrs. Ball, Baker, Rowe and Co.

This was seconded by Mr. JERRARD, and carried unanimously.

It was proposed by the Rev. H. REVELL REYNOLDS, seconded by Mr. JOSEPH CASH, and carried unanimously, that the Directors' fees for the coming year should be fixed at £200, this sum to be divided among the Directors as they think fit.

A vote of thanks to the Chairman terminated the proceedings.

The Anglo-American Brush Electric Light Corporation (Limited).

Report of the Directors to be submitted to the shareholders at the eighth ordinary general meeting, to be held at the Cannon-street Hotel, London, E.C. (Alexandria Hall), on Wednesday, March 13, 1889, at 12 o'clock noon :—

2. In view of the fact that, since the date of the last general meeting, two interim reports have been issued to the shareholders, the Directors consider that the usual *résumé* of the year's work admits of some curtailment in this instance, and they now confine themselves chiefly to a statement of the present position of the Corporation, and to an explanation of the yearly accounts.

3. In the special report of the 18th July last the Directors explained in some detail the circumstances attending the litigation with the Edison and Swan United Electric Company in regard to incandescence lamp patents, and reported the decision which Mr. Justice Kay had given in favour of the Corporation on the Edison patent.

4. The interim report of the 3rd October last contained a general statement of the position and prospects of the Corporation at that time, and of the work accomplished during the first nine months of the year.

5. The Directors are glad to be able to announce that the expressions of confidence with regard to the future of electrical industry contained in their previous reports are fully borne out by the progress effected during the past year. An extensive and more genuine demand for electric light and power has made itself evident, to the great benefit of the industry generally, and to the Corporation individually, as will be seen from the satisfactory character of the accounts now presented of the Corporation's affairs.

6. It is now generally admitted that the amendment of the Electric Lighting Act of 1882, which extends more favourable terms to the electrical contractors, and thus justifies the investment of capital in central installations for the supply of electric current, will produce highly beneficial results. As a matter of fact, although only a few months have elapsed since the Amendment Bill introduced by Lord Thurlow became law, considerable impetus has already been given to the business, and there is now much greater activity in all branches of the industry.

7. The improvement in the general position of the Corporation which has followed upon the revival of business in this direction is, however, not yet exhibited in the accounts now submitted, as the orders which have been received in connection with the supply and erection of plant for

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central stations are still in progress. The marked improvement which is seen from the accounts is due almost entirely to the growth of the ordinary business.

8. There are also indications that the amendment of the Electric Lighting Act will have a salutary effect in other directions, and by inspiring renewed confidence, tend to establish a better understanding among the various electrical manufacturers and contractors. United action where common interests are involved is greatly to be desired, and a diminution of the unhealthy competition which has prevailed during the recent depression is necessary to enhance the profits of the business. The formation of an electrical trades section of the London Chamber of Commerce, affording as it does opportunities to the principals in the various electrical firms for discussing common interests, is a step in these directions.

9. The result of the past year's work is, under all the circumstances, highly satisfactory. As compared with the previous year, the volume of business shows an increase of about 38 per cent. and the gross profit an increase of 70 per cent., while the standing charges have increased by only about 7 per cent.

10. The net balance of profit, after providing for depreciation and bad debts, is £12,885. 4s. 9d., which is equal to more than 5 per cent. upon the entire capital of the Corporation.

11. It is to be remarked that this profit has been earned almost entirely upon the ordinary transactions of the year, and does not include the profit accruing from the central station work now in hand, and that there are still other important fields from which the Corporation are able to derive revenues. The shareholders will therefore recognise that the business of the Corporation is now not only established on a reliable profit-earning basis, but that very sanguine expectations with regard to the future development of the business and payment of dividends are justified.

12. The contracts carried out by the Corporation during the year include important work in almost every department of the electrical industry.

13. The lighting of the Melbourne Centennial Exhibition, which proved eminently successful, and comprised the largest installation of the kind yet erected, was carried out almost entirely by means of the Corporation's apparatus, supplied at very short notice to the Australasian Electric Light, Power and Storage Company.

14. The contract secured for the arc lighting of the main building and grounds of the Glasgow Exhibition of 1888 was carried out to the thorough satisfaction of the Executive Committee, as will be seen from the following letter received from Sir W. Thomson :—"As Chairman of the Lighting Committee of this Exhibition I have much pleasure in intimating to you my entire satisfaction with the manner in which your contract was carried out. During the entire period the 520 arc lamps installed by you have worked with the greatest regularity and steadiness."

15. The illuminated fountain installation effected by the Corporation at the Barcelona Exhibition formed one of the most attractive features of the Exhibition, and was universally described as far surpassing all previous similar undertakings. This contract met with the entire approval of the Exhibition authorities, who have given the Corporation their highest award of a gold medal.

16. The Corporation have also been awarded a diploma in respect of their contract for lighting part of the Brussels Exhibition.

17. Amongst the installations on ships completed by the Corporation during the year may be particularly mentioned those on board the Castle Mail steamers—"Rosslyn Castle," "Hawarden Castle," and "Norham Castle."

18. Numerous installations have been carried out in private residences, factories, shops, offices, theatres, and other premises throughout the United Kingdom and abroad, and particular reference may be made to the completion of an important incandescent installation of 1,000 lights at Blenheim Palace for His Grace the Duke of Marlborough, and also to the lighting of Professor Piazzi Smythe's residence at Ripon.

19. The negotiations with the Honourable Commissioners of Sewers for lighting the City of London have been continued ; and it is confidently expected that at an early date specifications will be issued and tenders invited for lighting various sections of the City, for which the Corporation will be in a position to submit a proposal with good prospect of success.

20. The advance in the different technical branches has been of a very marked character, and highly-important results have been achieved, notably the perfection of the alternating-current system of distribution, which enables electric current to be supplied economically over large areas without any risk of danger to the public. The Corporation have designed a complete alternating-current system which is now perfect in every detail, and has been in successful operation during the past year. This apparatus has met with great favour since its introduction, and is now being manufactured on a large scale.

21. The Victoria dynamo machine for running incandescent and arc lamps in parallel has been improved in design and mechanical construction, and is generally recognised as one of the most efficient machines for the purpose in the market. This dynamo has been found to lend itself admirably for use in connection with direct driving engines at slow speeds for installation on shipboard, and has been manufactured in large numbers for this application. The special engines supplied by the Corporation from the designs of their superintending engineer, Mr. Raworth, meet with a ready sale, and constitute an important feature of the business.

22. The Corporation's trade in incandescent lamps has been considerably extended, and their Victoria lamps have secured a wide reputation for durability and economy.

23. When the Cheesborough patent was upheld by Mr. Justice Kay, in the recent action of Edison and Swan *versus* Holland and Others, the Corporation at once devoted attention to the production of a lamp in which the Cheesborough process of flashing could be dispensed with, and their efforts were so successful that the present form of Victoria lamp ranks as one of the most efficient in the market.

24. The Directors are glad to be able to state that the action referred to in the last annual report, which the Corporation instituted in 1887 against the Orient Steamship Company, who were using dynamo machines made by Messrs. King, Brown and Co., of Edinburgh, in infringement of the Brush patent for compound-winding, was decided wholly in favour of the Corporation by Mr. Justice Chitty, in December last, and the Corporation were granted a certificate of validity of the patent, costs and inquiry as to damages. Meanwhile Messrs. King, Brown and Co. have brought an action in Scotland for the revocation of the patent, and this case is now before the Court.

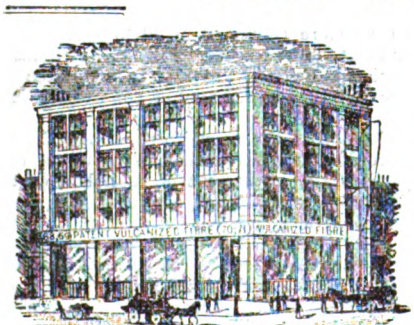
25. With the above exception every dynamo manufacturer of importance in the country has recognised the Corporation's claim, and the royalties now received constitute an important source of revenue. In this matter the policy of the Directors has been, while not harassing the trade or interfering with the growth of the industry, to protect the interests of the shareholders by charging a small royalty for the use by others of the Corporation's patent. The Directors, however, have no alternative but to resort to legal procedure when the usual commercial methods of protecting the Corporation's rights and of enforcing their just claims fail.

26. The action of the Edison-Swan Company against the Corporation for alleged infringement of the Edison patent in the manufacture of Victoria incandescent lamps is now under appeal to the House of Lords, the Court of Appeal, which had previously decided in favour of the Edison patent in the case of "Edison and Swan Company *v.* Woodhouse and Rawson," having recently reversed the decision which Mr. Justice Kay gave after a most exhaustive hearing extending over 22 days. In view of the fact that the House of Lords will not be bound by the decision of the Court of Appeal in the Woodhouse and Rawson case, and that the issue to be raised will in many respects be a new one, the Directors are advised that there is every prospect of the decision of Mr. Justice Kay in favour of the Corporation being sustained.

27. The Directors deeply regret the existence of this litigation, which is not only costly but is a very great disturbance to the proper conduct and development of the ordinary business. Litigation is, however, not always avoidable, and that relative to incandescent lamp patents has been rendered necessary by the action of the Edison-Swan United Electric Light Company. That company and the Corporation both hold patents for the manufacture of incandescent lamps, and it has always been the earnest desire and endeavour of your Directors to respect the interests of the two companies and of the industry generally by effecting a settlement equitable and honourable to all parties. In this effort, however, they have not as yet been successful, and have had no recourse but, in the interest of the shareholders, to defend to the utmost the action instituted by the Edison-Swan Company.

28. The Corporation have much to gain in the future by freedom from interference in their business as manufacturers of incandescent lamps under the various patents they hold, but unlike the Edison and Swan Company they do not rely for their revenue mainly upon the manufacture of these

THE NON-CONDUCTOR OF ELECTRICITY.



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This new material is supplied in two qualities, Flexible and Hard.

The **FLEXIBLE** is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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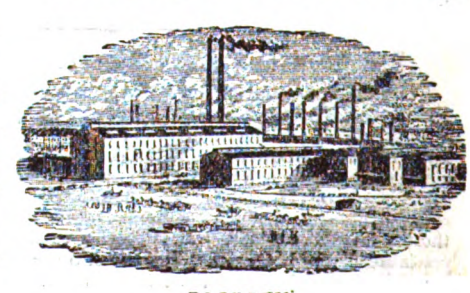
Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.



FACTORY.

MOSSES & MITCHELL, 70 Chiswell-st., London, E.C.

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lamps, inasmuch as the Corporation's trade in these articles at present amounts to scarcely 10 per cent. of the total volume of their business.

29. The capital account shows an increase of £4,640, which arises out of the issue, under the resolution passed at the general meeting in February, 1887, of 1,160 new shares.

30. The increase in the patents, development, and goodwill account of £1,749. 1s. 10d. is due to development of new inventions, and to the usual annual payments for maintenance of existing patents.

31. The profit and loss accounts includes a satisfactory profit derived from the Austro-Hungarian branches. This new department of the business has, during the past year, developed in every way satisfactorily, and bids fair to prove an important source of income in the future. The central lighting stations worked by the Corporation are now also yielding good profits.

32. The Directors consider the present a fitting opportunity for taking a general survey of the advance made during the five years which have elapsed since the reduction of capital in 1884, and with this view they submit a diagram showing the fluctuations during that period in the volume of the business, the general charges or expenses of management, and the gross profits.

33. To facilitate comparisons between one year and another, the actual figures are shown on the diagram in percentages, the figures for the year 1883 being taken as represented by 100. It will be seen that the volume of business in 1888 is to that of 1883 as 307 is to 100, showing an advance in the five years of upwards of 200 per cent., and while the gross profits have increased in the ratio of 100 to 342·9, or over 242 per cent., the standing charges have *fallen* in a ratio of from 1 0 to 65.

34. The above figures do not take cognisance of the business effected through the Continental branches. If this be added, as shown in the diagram by means of dotted lines, it will be seen that the advance of the Corporation's business is even more satisfactory, notwithstanding that the standing charges are relatively higher on the Continent than in England, which is due to the fact that the business carried on there by the Corporation is still young ; and it is probable that a much larger amount of trade could be effected without any material increase in the expenses of management.

35. The Directors think it will be recognised by the shareholders not only that the affairs of the Corporation have, during these five years, been conducted with energy and economy, but that, having regard to the hitherto undeveloped condition of the industry, and consequent difficulty and expense of working up a new business, the results must be considered as highly satisfactory and encouraging.

36. With regard to the prospects for the current year, the Directors have every confidence in a still further improvement, the orders during the first two months of this year being more than double the orders received during the corresponding period of any previous year.

37. The Directors who retire this year by rotation are Lord Thurlow and Colonel Steuart, who, being eligible, offer themselves for re-election. Messrs. Cooper Brothers and Company, the auditors, also retire and offer themselves for re-election.

NEW COMPANIES REGISTERED.

RAILWAY AUTOMATIC ELECTRIC LIGHT SYNDICATE (LIMITED).—This syndicate was registered on the 26th ult., with a capital of £10,000, in £25 shares, to produce and supply electric light, and for such purposes to adopt an agreement on the 14th ult., between D. H. Davies and John Tourtel of the first part, James Ernest Spagnoletti and Joseph Crookes of the second part, and W. H. England of the third part.

GREAT MARLOW WATER COMPANY (LIMITED).—This company was registered on the 25th ult., with a capital of £16,000 in £10 shares, to supply the town and neighbourhood of Great Marlow with water, gas, and electricity. Registered without special articles.

NOTTINGHAM ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—This company was registered on the 27th ult., with a capital of £100,000, in £10 shares, 100 being founders' shares, to carry on at Nottingham the business of an electric light and power company. The number of directors is not to be less than 3 nor more than 9 ; the subscribers are to appoint the first ; qualification, 25 shares, or £250 stock ; remuneration, £400 per annum and 10 per cent. of the annual net profits, after providing for 7 per cent. dividend, to be divided as they may determine.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 1st, 1889, amounted to £5,327.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of February was 4,151, estimated to produce £3,200, against 4,535 messages, producing £3,666 in the corresponding month of last year. The traffic receipts for the month of November, estimated at £3,100, realised £3,107.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February are estimated at £2,008, as against £1,858 in the corresponding period of last year. The Board have, upon the audited accounts for the half year ended 31st December last being submitted to them, decided to recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 4 per cent. per annum on the Ordinary shares (free of income-tax), making, with the previous distribution, a divi- at the rate of 4½ per cent. for the year 1888 on the Ordinary shares, against 4 per cent. in 1887, and to carry forward £723. 5s. 3d. to next account.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company are as follows :—February, 1889, £19,600 ; January 1st to February 28th, 1889, £42,000 ; corresponding months, 1888, £41,600 ; corresponding months, 1887, £39,600.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February were £54,611, as compared with £51,261 for the same period last year, or an increase of £3,350.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February were £37,584, as against £38,795 for the same period last year.

THE NEUCHÂTEL TELEGRAPH WORKS.—The important telegraph and electrical apparatus works at Neuchâtel, which have up to the present been under the management of Dr. Hipp will in future be carried on by MM. Peyer and Favarger ; but Dr. Hipp will continue to render technical assistance.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The traffic receipts of this company for the month ended 28th February, 1889, amounted to £5,900.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 1st, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,467.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended February 28th, 1889, were £2,696, against £3,201 for the corresponding period last year. November receipts, estimated at £5,203, realised £5,238.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY
SOLE PROPRIETORS of the British, Indian and Colonial Patents.
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87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Mar. 6, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Mar. 6, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£ 1,770,380	Stock	15 0	Anglo-American	49½ 50½	3 4 5	Jan., Apr., July, Oct.	50	49⅜
2,614,820	Stock	30/0	Do. Preferred	83 84	3 17 5	,, ,,	84	81⅝
2,614,820	Stock	15/0	Do. Deferred	16¾ 17½	...	February	17⅜	16¼
130,000	£10	3/0	Brazilian Submarine	13⅜ 13⅝	5 1 0	Mar., June, Oct., Dec.	13⅝	13⅛
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	101½	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14 14½	6 4 2	February and August	14	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	3⅞	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9⅞ 10¼	3 19 0	Jan., Apr., July, Oct.	...	...
380,000	10	2/6	Eastern	13 13¼	4 10 7	,, ,,	13¼	13
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	15½	15¼
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	107¾	107
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	108½	107
250,000	10	2/6	Eastern Extension	13 13½	4 18 4	Jan., Apr., July, Oct	13¼	13 1/16
3 0,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
47 ,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	102⅛	...
179,177	10	1/3	Globe Telegraph and Trust	6¾ 7⅛	5 1 9	Jan., Apr., July, Oct.	7¼	7
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14 7/16	14¼
150,000	10	5/0	Great Northern	15 15⅛	4 16 9	Jan., July, and April	15½	15⅛
17,000	25	12/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	6½ 7	5 14 3	April and October	6⅞	...
15,609	10	3/0 1887	West African Telegraph	6 7	2 2 10	...	6½	6¼
300,000	100	5%	Do. 5 per Cent. Debentures xd	100 103	4 17 1	March & September	101	100½
30,000	10	6/0	West Coast of America	9¾ 10¼	4 17 7	January and July	10 1/16	10
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜ 1⅝	...	...	1½	...
34,563	10	12/6*	Do. 1st Preference 6%	11 11½	...	April and October	11½	11¼
4,669	10	+	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6 0	Western Brazilian	13½ 14	5 7 3	March & September	13 1/16	13½
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds xd	100 102	5 17 8	March & September	102¼	...
			TELEPHONES.					
224,850	14/0	5%	Consolidated Telephone and Maintenance	¾ ⅞	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	⅜ ½	2 14 11	...	...	...
80,000	5	5/0	United	14¾ 15	5 0 0	June and December	15	14 15/16
55,000	5	3/0	United River Plate	5⅝ 5⅞	...	January and July	5⅞	5 13/16
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3½ 3¾	...	...	...	...
23,692	5	2/0	Do. (fully paid)	4¼ 4¾	...	February & August	4 1/16	4½
79,934	5	nil.	Swan United (£3. 10s. paid)	2¾ 3	...	...	2¾	...
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance xd	40 42	5 14 3	March and July	41⅜	41¼
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works xd	17½ 18½	5 8 1	February & August	18½	18⅜

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
Hammond & Co.
J. G. Statter & Co., Limited.

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MANVILLE & MADGEN, *Managing Directors*

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 565.—Vol. XXII. FRIDAY, MARCH 15, 1889. Price Fourpence.

NOTES.

Dr. Lodge's Friday evening lecture "On the Discharge of a Leyden Jar," at the Royal Institution, attracted a large and distinguished audience, and was listened to with marked enthusiasm. The lecturer succeeded admirably well in the somewhat difficult task of handling his subject so as to interest both the scientific and the *dilettanti* elements of which a Royal Institution audience is made up. There is no need to attempt a description of the lecture here, since it is printed verbatim in the present issue. We may, however, remark that the experiment of lowering the frequency of oscillation until the discharge gives rise to a musical tone of definite pitch was markedly successful. It is done simply by increasing at once the capacity of the condensers and the self-induction of the circuit; the experiment may very easily be repeated by anyone who has the necessary apparatus at hand. The self-induction must, however, be obtained from a solenoid without iron, for even at the comparatively moderate frequency of 1,000 per second the effect of iron, however much laminated, is rather to diminish than to increase the inductance. The "musical spark" will no doubt form a favourite lecture experiment in future.

Whilst Dr. Lodge was illustrating the effect of increasing the length of the discharging circuit in exaggerating the length and noise of the spark, some excitement was caused amongst the audience by the discovery that electric discharges of a vigorous character were taking place at various points upon the walls of the room. It happens that the Theatre of the Royal Institution is hung with wall-paper having a gilt oak-leaf pattern, and thus it forms a sort of "spangled-pane." It is probable that the electric radiations, on being reflected from the walls, gave rise to secondary disturbances, which became visible as described. When the lights were turned down the phenomenon was very brilliant.

In the library of the Royal Institution an experiment recently discovered by Dr. Lodge, and closely akin to the famous Hertz phenomena, was exhibited. This was the excitation of minute but easily visible discharges in a circuit having a suitable time-constant when placed anywhere in the neighbourhood of a Wimshurst machine in action. When the time-constants of the two circuits are approximately equal, the successive impulses accumulate in the secondary circuit until at last the dielectric breaks down in the form of a visible discharge. That this is a radiation effect as distinguished from ordinary induction was made evident by *increasing* the self-induction of the secondary. This had the effect of suppressing the discharge altogether, whereas any effect of ordinary induction would have been of course augmented.

In an important Paper by Prof. J. J. Thomson, published in the last number of the *Proc.* Roy. Soc., it is shown that this very experiment affords a crucial test of the truth of Maxwell's theory, as against the modification introduced by Helmholtz. According to the latter view (in which the ether is assumed to possess a slight degree of compressibility) it is now shown by Thomson that in a circuit exactly similar to that used by Lodge in this experiment the time of vibration would be independent of the capacities of the ends. But Dr. Lodge, though apparently unaware of Prof. Thomson's demonstration, actually showed that when the self-induction of the circuit was changed the resonance effect could be restored by a suitable change in the size of the discs on which the wire terminated. This experiment, therefore, affords, in the words of Prof. Thomson, "exceedingly strong testimony in favour of the truth of Maxwell's theory, at any rate for conductors."

At the Physical Society on Saturday, Dr. Lodge did not get time to go over the entire programme which had been arranged, and he therefore virtually confined himself to a repetition of the experiments of the previous evening with a development of the theory. The beautiful phenomenon of the rotation of the plane of polarisation in alternate directions by the Leyden jar discharge gave rise to a discussion of great interest. We are compelled to hold over our report of this meeting until next week.

There is a general concensus of opinion in the English press that the collapse of the French Copper Syndicate is complete and final. Certain it is that an enormous amount of the "cornered" metal remains on hand far in excess of present requirements; and almost equally certain is it that the Syndicate will have to part with its store at considerable loss. To prevent this loss being too great, or, as the financial newspapers prefer to put it, to prevent the market being utterly demoralised by a glut of copper suddenly thrown upon it, an English Syndicate is said to have come to the rescue, and we are asked to believe that the supply will be doled out at reasonable prices. We are

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not conversant with the mysteries of the Copper Market, but, speaking as ordinary laymen, we should say that it is just as impossible for an English as for a French ring to maintain, for any length of time, prices at which consumers are not disposed to buy; and with a known supply largely exceeding their demand purchasers are pretty certain to hold off until the commodity is offered, not at its natural value, but at the value to which these recent operations have unnaturally reduced it. In other words, copper ought to be exceedingly cheap, and we fail to see how anybody can prevent its being so in the long run.

We hope and believe that the person who prompted the question put to the Postmaster-General on Monday evening relating to the Submarine Telegraph Company's servants did not represent the whole body of postal telegraph operators at the Central Office. A more ungracious suggestion with regard to an unfortunate body of men of the same profession as themselves could hardly be conceived. The Submarine Company's *employés* are in a far worse plight, through no fault of their own, than were the servants of the old telegraph companies before they were handed over to the Post Office; and to place any sort of hindrance to the Submarine clerks being fairly, and even handsomely, treated by the Government is, to our thinking, inexpressibly mean. We repeat, however, our suspicion that the question was concocted by some self-constituted delegate who knows little of the feelings of his comrades, and still less of the character of the Postmaster-General.

On Wednesday last, at the invitation of the Series Electric Traction Syndicate, a number of representatives of the technical journals proceeded to Northfleet for the purpose of inspecting the working of the electric tramway which has just been completed by the Syndicate in that locality. The line is of no great length (rather under one mile), but it contains a long gradient of about 1 in 32, and several sharp curves, so that it affords every opportunity for testing the capabilities of the system. The running of the two cars left nothing to be desired in point of speed and perfection of control, and, in fact, the whole of the arrangements created a most favourable impression upon the minds of the visitors. Very great skill has been displayed both in the engineering and the purely electrical details, especially in the arrangement of the conduit to form one of the running lines; indeed, we believe that an inspection of the line would go far to dissipate any lingering prejudice which may exist in the minds of our readers against the principle of series working. The fact that by the action of the arrow the "spring-jack" contacts are not only automatically kept bright, but that an incipient fault is at once disclosed and localised by the reading of the ammeter on the car, added to the further fact that the "spring-jacks" can be replaced in five minutes at a trifling cost, seems to us to render it, to say the least, highly improbable that the numerous advantages of the system will be to any sensible degree counterbalanced by the difficulty of maintaining the numerous contacts. We therefore look forward with some degree of confidence to an extensive development of this system.

On Friday last, too late for our current number, we received the following cablegram from our New York correspondent:—

[Cablegram.]

"News received from Canada this morning that Edison lamp patent in the Dominion has been declared void there on account of failure to comply with provisions as to manufacture in the Dominion within a year of issue."

The action in question was brought by the Westinghouse Electric Company and the United States Electric Company. Some further particulars of the case will be found in our issue of Dec. 28th, 1888, page 214.

We print on another page the full text of the report of the Committee on Underground Conduits and Conductors appointed in 1888 by the American National Electric Light Association. The subject is one of the greatest possible interest to English electricians at the present time, and the report merits their most careful consideration. It should, however, be clearly understood, although it is not explicitly stated, that the investigations of the Committee were really confined to the case of high potential circuits. The Edison low potential system of underground mains, with its elaborate devices for securing flexibility as well as insulation, though expensive, has proved a practical success from the first, and the possibility of working circuits of low potential in underground conduits is not called in question. But for currents of high potential the case is different. It will be seen that a circular containing a well-considered series of questions was sent by the Committee to 130 local electric lighting companies in the States. Out of this number no less than 104 replied that in their opinion it is not yet practicable to place wires conveying high-tension arc light currents underground. Of course the value to be attached to this expression of opinion must be suitably discounted by the recollection that all these companies had their capital invested in overhead systems. And it is even possible to suppose that the unanimity of their replies was intended to influence public opinion. On the other hand, the views of seven companies who are actually operating underground conductors of greater or less extent are given in detail in the report. Of these seven the experience of five is strongly adverse to the system, one other had only been in operation a few days, and one solitary individual is able, on the whole, to speak in its favour, though he, too, had had his troubles. A somewhat acrimonious discussion followed the reading of the report, one or two representatives of special conduit devices moving its rejection. It was, however, clear that the general body of members were fully prepared to endorse the action of the Committee.

In this matter, whilst we can only re-echo the advice of Prof. Forbes, that the experience of our American cousins should be duly pondered, yet there are, we think, some considerations of a reassuring character. In the first place, underground mains conveying high tension currents have already been maintained in this country with some degree of success—notably by the Eastbourne Electric Light Company, and, at an earlier date, by the Anglo-American Brush Company in the lighting of the City. It may be relied upon that this experience will not be

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thrown away. Next, there are some difficulties, such as those occasioned by steam pipes, existing in many American cities, which do not affect us in this country. And lastly, but not least, there is the question of insulation. In America the competition amongst arc-lighting companies is so keen that it would be almost impossible to get a return upon the capital invested if a really high-class insulation were employed. This point was fully admitted in the discussion to which we have alluded. Prof. BARRETT, of Chicago (who had not replied to the circular of the committee) pointed to seven miles of successful underground high potential mains, whilst at the same time he admitted that the extra cost, as compared to an overhead system, amounted to nearly one cent. per lamp per hour. (This calculation is not quite intelligible without further explanation, but we quote it from the report furnished by the American journals.) The system is, however, in the hands of the municipality, and is practically free from commercial competition.

OUR Brussels correspondent informs us that the Municipality of that city have decided to throw open the supply of electric light to public tender. The principal conditions which are imposed will be found in his letter.

WE do not know who is responsible for "the particulars and information furnished" to the Electric Lighting Committee of the Cheltenham Town Council, an abstract of which appeared in our last issue; but we do know that a calculation of revenue based on an estimate of 1,500 hours of burning per annum for every incandescent lamp is in the highest degree fallacious. Experience both in this country and in America has shown that a usage of from 700 to 800 hours per annum is a fair all-round average. But the Cheltenham people would probably do well to be guided by the experience of Leamington—the two towns being very much alike—where it has been found that the private consumers burn their lamps upon the average rather less than 500 hours per annum. We are glad that Cheltenham is alive to the advantages of electric lighting, and we sincerely hope that the Council will see their way to carry out the wishes of the inhabitants; but it is to the interest of all concerned that they should not be misled by financial estimates which will certainly fail to be realised.

THERE is just one remark in the interesting and encouraging speech of the Chairman of the Anglo-American Brush Company to which we venture to demur. Lord THURLOW thinks that "the recent advance of electrical science" is due to the Electric Lighting Act of 1888; but he omitted to explain the exact connection.

London Central Subway Railway Bill.—This Bill was read a second time in the House of Commons on Friday last.

St. Martin-in-the-Fields Vestry.—At a meeting of this Vestry last week it was decided to support the Provisional Order of the Electrical Power Storage Company.

St. John's (Newfoundland).—According to the *Canadian Gazette*, the streets of St. John's are being lighted by the electric light, as well as Government House and the Parliament buildings.

Balloon Signalling.—Further experiments are to be carried out shortly at Chatham by the Balloon Department with the Bruce system of electric balloon signalling. The apparatus used will be that purchased by the Government of the inventor, Mr. Eric Stuart Bruce.

Metropolitan Railway Bill.—This Bill, which empowers the company to use electricity as a motive power and to enable them to run over the Aylesbury and Buckingham Railway, passed the Examiner upon Standing Orders in the House of Commons on Monday last.

The Electric Light at Windsor Castle.—The introduction of the electric light into the corridor at Windsor Castle has been found so great an improvement that it will be extended before long to the White, Crimson and Green Drawing-rooms, the ball-room, and the dining-room.

Society of Arts Motor Trials.—In reference to the recent trials, under the auspices of the Society of Arts, of motors suitable for electric lighting purposes, Professor Kennedy will read a Paper on the subject at the Society of Arts on Wednesday next, when the medals will be presented to the competitors.

Metropolitan Electric Supply Company.—In the House of Commons on Tuesday last, the Committee of Selection decided that the Metropolitan Electric Supply Company's Bill should be taken out of the original group and not go before committee until the London County Council was in operation to give them consideration.

Recent Floods and the Telegraph.—Some damage was done to the telegraph wires and poles by the snowstorms and floods in the Midland and Western counties last week, causing partial interruption and delay to the places north of Birmingham. The injuries were, however, speedily repaired, being very much less serious than they were reported to have been in the newspapers.

The Forth Telegraph Cables.—Telegraphic communication with the North of Scotland has been somewhat interrupted of late by the breakdown of the submarine cable which crosses the Forth between Burntisland and Granton. This has necessitated a visit from the Government cable steamer "Monarch," which is now in the Forth, and is engaged repairing the old and laying a new cable.

St. Saviour's Board of Works.—At a meeting of this Board last week it was decided, on the recommendation of the General Purposes Committee, to consent to the application for Provisional Orders for supplying electricity in the district being made on behalf of the Metropolitan Electric Supply Company and the London Electric Supply Corporation, subject to certain restrictions being allowed.

Lighting of the Hoosac Tunnel.—The leads finally adopted for the electric light installation at the Hoosac Tunnel, Mass., were made by the Standard Underground Cable Company, forty miles of lead-covered cable being laid in wooden conduits in trenches on each side of the tracks. Several kinds of special insulation were tried, but the excessive moisture and sulphurous fumes proved too much for them.

"Electrical World."—During the recent meeting of the National Electric Light Association at Chicago, our contemporary, *The Electrical World*, of New York, issued a "bulletin" twice a day giving a report of the proceedings. These bulletins have been embodied in the current issue of *The Electrical World*, which contains no less than 96 pages. (*The Electrical World* can be obtained at the office of *The Electrician*.)

Dudley.—At the monthly meeting of the Dudley Town Council last week Alderman Bagott, in moving the report of the Streets and Gas Committee, begged the Council to do all in its power to get up a competitive light in the borough. Several members advocated the electric light. After a long discussion on the high price of gas in Dudley, it was unanimously agreed to ask the gas company for a reduction in the prices charged.

Newcastle.—The recommendation of the Town Improvement Committee that the proposed Licences of the Newcastle and District Electric Lighting Company and of the Newcastle Electric Supply Company should be supported, was considered at a meeting of the Newcastle City Council on the 6th instant.

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After some discussion, the report of the committee was adopted, with the addition of a clause prohibiting a transfer of the Licenses.

Halifax.—The Electric Lighting Committee of the Halifax Town Council met again on Wednesday to consider the various applications for a concession to supply the electric light, but we understand no decision was come to. In the meantime Messrs. Schmidt, Douglas and Co., and Messrs. Blakey, Emmott and Co., are busy canvassing, and the latter firm have already got to work by supplying lights in Corn market, Market-street, and Northgate.

A New Alloy.—A new alloy has been made by Herr Reith, of Bockenheim, Germany, which is said to practically resist the attack of most acid and alkaline solutions. Its composition is as follows:—Copper, 15 parts; tin, 2·34 parts; lead, 1·82 parts; antimony, 1 part. This alloy is, therefore, a bronze with the addition of lead and antimony. The inventor claims that it can be very advantageously used in the laboratory to replace vessels or fittings of ebonite, vulcanite, or porcelain.

Institution of Electrical Engineers—Students' Meeting.—A meeting was held on Friday, March 8th, at 8 p.m., Mr. Guy C. Fricker, A.I.E.E., in the chair. The discussion on Mr. H. W. Handcock's Paper on "Ship Lighting and the Aspects of Electrical Industries in the Colonies" was opened by Mr. J. Rance, Jun., and continued by the Chairman and Messrs. Müller and Childs. Mr. Handcock replied, and a vote of thanks to Mr. Fricker for presiding terminated the proceedings.

Obituary.—We regret to learn that Mr. Joaquin de Mancha, Chairman of the Cuba Submarine Telegraph Company, died suddenly on Sunday morning, the 10th inst., at his residence, Springfield, Clapham Park. Mr. de Mancha, who was head of the firm of Messrs. Mancha and Co., Spanish merchants, joined, by invitation, the Board of the Cuba Submarine Telegraph Company in 1874, and was elected to the chairmanship on the retirement of Mr. Hughes, Q.C., in 1882. He was in his 71st year.

Clerkenwell Vestry.—At a meeting of this Vestry last week the Works Committee reported upon the applications from the London Electric Supply Corporation and the Metropolitan Electric Supply Corporation for the consent of the Vestry to their Provisional Orders. The committee recommended "That the terms and conditions be approved, and that no opposition be offered to the application for Provisional Orders, and that the companies be informed that the Vestry deem it desirable that a station for generating electricity should be in this parish." The motion was adopted.

"Work."—The first number of a new weekly journal, entitled "Work: an Illustrated Magazine of Practice and Theory for all Workmen, Professional and Amateur," will make its appearance on the 20th of March. We are led to expect that in the pages of "Work" will be found a clear and practical exposition of methods to be followed in every art, craft, and science that bears directly or indirectly on handiwork of a constructive or decorative character, freely illustrated with sketches, diagrams, or working drawings to scale. Messrs. Cassell and Company are the publishers.

Sheffield.—The Sheffield Telephone Exchange and Electric Light Company have recently completed some extensive structural alterations at their works in Station-road, by which the size of the engine and machine rooms and the capacity for output have been more than doubled. Additional plant has also been laid down, comprising a 100lbs. pressure steel boiler and a horizontal condensing engine, which drives a 35,000 Watt-Mordey alternator. The demand for light is growing very rapidly, and, amongst other places, the hotel which the Café Company will open shortly in Fargate is to be lighted throughout by electricity.

Prof. Forbes' Paper on "Central Station Lighting"—Some Corrections.—Prof. G. Forbes requests us to make the following corrections to Part II. of his Paper on "Central Station Lighting," as issued by the Institution of Electrical Engineers:—P. 507, column 1, line 9, for "57 yards," read "40 or 50 yards"; p. 508, column 1, line 15, for "the waste due to magnetic friction . . . . . induction in the iron is the same," read "the waste due to magnetic friction varies as the length of the magnetic circuit, if the induction in the iron is the same"; p. 508, column 2, line 33 from end of article, for "great," read "frequent."

Indian Telegraph Department.—The annual Administration Report of the Indian Telegraph Department shows that 5,014 miles of new wires and cables were laid during the past year, making a total of nearly 94,000 miles. The net revenue from the telegraphs was over 23 lacs, being the largest ever recorded, and more than 50 per cent. over the average of the three previous years. Over 2,800,000 messages were sent, an increase of nearly 12 per cent. on the year 1886. The reduction in charges for telegraphic money orders has resulted in a great development of this traffic. The excellent services rendered by Sir A. Leppoc Cappel, the retired Director-General, are acknowledged by Government.

The Royal Meteorological Society's Exhibition.—The Royal Meteorological Society's tenth annual exhibition of instruments will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, in conjunction with the society's meeting on Wednesday, the 20th inst., and will be very interesting and instructive. The exhibition is specially devoted to actinometers and solar radiation apparatus. It will also include several new instruments, and a number of photographs of flashes of lightning, clouds, &c. The exhibition will remain open till Friday, the 22nd inst. Persons, not Fellows, wishing to visit the exhibition can obtain tickets on application to Mr. W. Marriott, Royal Meteorological Society, 30, Great George-street, S.W.

Exports of Telegraphic Wire and Apparatus connected therewith.—The figures shown by the last Board of Trade returns are not altogether unsatisfactory, though they do not amount to one-third of the value of the exports for January, which, it will be remembered, were quite exceptional. The following is a comparative statement:—

	1886.	1887.	1888.
Year	£992,667	£817,385	£521,174
	1887.	1888.	1889.
January.....	£14,442	£41,231	£113,230
February	44,137	14,051	32,086
Two months.....	£58,579	£55,282	£145,316

St. Margaret's and St. John's (Westminster).—At a meeting of this Vestry last week the Parliamentary Committee reported that they had had the following electric lighting schemes before them: Kensington and Knightsbridge Electric Lighting Company, Metropolitan Electric Supply Company, London Electric Supply Corporation, Westminster Electric Lighting Company, St. George's (Hanover Square) Electric Lighting Company, and the House-to-House Electric Light Supply Company. They recommended that objections should be lodged against the whole of them. The committee was still proceeding upon the reference by the Vestry, empowering them to fully inquire into the whole question of electric lighting, with a view to the Vestry undertaking the supply of the light in that district themselves. The report and recommendations were unanimously adopted.

The Liquefaction of Gases by Electricity.—An electrolytic method of liquefying gases has been described by H. N. Warren in the *Chemical News*. Strong hydrochloric acid is introduced into a combustion tube, bent at right angles, so as to cover two small platinum plates fused into the closed end of the tube; a plug of asbestos, saturated with concentrated sulphuric acid, is placed at the bend; the open and shorter arm is then fused up and immersed in a freezing mixture. On the passage of a current through the plates gas is evolved and liquefies at the other end; but on removing the tube from the freezing mixture and discontinuing the current the liquefied hydrogen chloride is reabsorbed by the water. The experiment may then be repeated. Other compound gases behave in a similar manner. When acidified water is decomposed in this apparatus, and a platinum plate covered with platinum-black has been fused in the short end, explosions occur there at intervals, and small quantities of water form, containing hydrogen peroxide, and having an

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ozonised odour. With chromic acid and water the blue oxide of chromium is obtained. The method has also been applied to the liquefaction of oxygen and hydrogen, and the latter is said to have been "decidedly liquefied."

Continuous-Current Machines by Ganz and Co.—For the last two years the firm of Ganz and Co., of Buda Pesth, have been building continuous-current machines with drum armatures. The following table gives some data with regard to these machines:—

Data.	No. 0.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Maximum power in watts	1,650	3,000	7,200	10,800	22,000	44,000
Maximum current in amperes ..	15	60	120	180	200	400
Difference of potential in volts..	100–110	100–110	100–110	100–110	100–110	100–110
Revolutions per minute	1,400	900	700	600	500	375
Diameter of commutator in mm.	110	130	156	170	170	26
Length of commutator in mm. ..	80	90	130	126	134	178
Total weight of machine in kg...	240	490	880	1,150	2,100	4,400
Percentage electrical efficiency ..	89·5	91·3	93·5	93·6	95·2	96·1
Percentage commercial efficiency	79·5	84·7	88·6	89·0	92·0	93·6
Number of 64 watt 16 c.-p. lamps	23	52	105	158	312	625
Armature induction in C.-G.-S. units	13,900	12,800	14,400	14,700	13,900	15,100
Total weight of copper in kg. ..	11·3	23·6	39·1	59·7	113	258
Power in watts per kg. of total weight	6·9	7·4	8·6	9·4	10·5	10
Power in watts per kg. of copper	146	153	184	181	195	171
Power in watts per kg. of copper on armature.....	920	600	710	570	600	650
Watts per effective h.p.	590	620	650	650	680	690

Meeting of the Electric Light Association at Chicago.—Up to the time of going to press the letter from our New York correspondent has not reached us. It would probably have contained an account of the proceedings of the ninth meeting of the National Electric Light Association at Chicago. With the exception of the report of the committee on underground mains, which we print elsewhere, the Papers read at this meeting are of less interest than usual to English readers. The following is a summary of the proceedings:—

President's Address. By S. A. Duncan.
Report of Committee on Patent Legislation. By A. Steuart.
Report of the Committee on Underground Conduits and Conductors. By E. T. Lynch, jun.
Report of the Executive Committee. By B. E. Sunny.
Electric Light Stations as Fire Risks. By S. E. Barton.
Report on the New England Electric Exchange. By P. H. Alexander.
Disruptive Discharges in Lead Cables. By C. H. Rudd.
Fuel Oil. By S. S. Leonard.
Oil as Fuel. By M. J. Francisco.
The Advantages of Oil as a Fuel. By C. M. Ransom.
Municipal Lighting. By F. H. Whipple.
Municipal Ownership of Natural Monopolies. By A. R. Foote.
Conduits: Their Material in Relation to Insulated Conductors. By A. C. Chenoweth.

Popular Lectures.—A series of three lectures on "Electricity in the Service of Man" is now being given by Mr. Lant Carpenter, at the Polytechnic in Regent-street. These lectures, which are delivered under the auspices of the London Society for the Extension of University Teaching, have so far proved a great success, as many as 1,250 persons being present. The audiences, moreover, have been largely composed of artizans. Last Friday Mr. William M'Whirter also delivered a lecture upon the same subject at Aberdeen. In the course of his remarks, Mr. M'Whirter referred to the wonderful progress of telegraphy. Great reductions, he said, had been made in the cost of telegrams. In 1840 the charge from London to Stafford or Birmingham was just under 4d. per word; to Liverpool, Leeds, or Manchester it was over 5d.; to York it was nearly 6d.; to Edinburgh it was just under 8d.; to Glasgow it was 8¾d.; and to Derby 4½d. In 1855 the number of telegrams sent was 882,360; in 1865 the number rose to 4,650,231; in 1875 the number of messages went up to 19¼ millions; and in the year 1885-86, when the sixpenny telegrams had been in force, the increase amounted to 47½ millions. The lecture was illustrated throughout by interesting experiments.

A Central Station at Strathearn.—The Strathearn Hydropathic Company are engaged in laying down what is practically a small central station in the Hydropathic Crieff. It is intended not only to light the Institution itself, but to extend the field of operations to several villas in the town, and to light the outhouses, and to supply power all over the building, and to a threshing machine in the stables. There is a great deal of water-power going to waste round the town, but the fashionable character of the locality decided the use of other motive power. The matter was placed in the hands of Mr. C. H. Yeaman, of London, and, after some careful tests at the manufacturer's works, the Griffin gas-engine of the double-acting type was decided on, and a 24 B.H.P. engine, running at 200 revolutions, is being laid down. The engine and accumulator rooms are directly under the main public rooms, but sunk several feet below any other part of the building. The dynamo employed is one of Messrs. Laurence, Paris and Scott's, of Norwich, giving 100 volts and 120 amperes at 850 revolutions. To start with, a little over 150 lights are being fitted, and the engine plant alone will be used. Messrs. Anderson and Munro, of Glasgow, are wiring the house, and are introducing their quick break switches and Trotter's dioptric globes.

The Overhead Wire Question in Brooklyn.—The Board of Commissioners of Electrical Subways has recently published its report for 1888. The aggregate length of conductors underground has been increased from 1,433 to 2,928 miles. There are now 2,978 miles of wire underground, with 5,117 miles of aerial conductors, against 4,659·2 miles, all aerial, in 1886. Of the aggregate 5,117 miles of aerial conductors, those of the various district telegraph companies and of the Gold and Stock Telegraph Company occupy house-tops and not poles, and the Board has permitted their operation because of the difficulty of concentrating this small but scattered mileage in conduits. There are 4,402 miles of telegraph and telephone wires more immediately the subject of the operations of the Board. "Of this amount it is reasonable," says the report, "to expect that nearly all of the 236 miles of the telegraph wires now carried on poles will be removed. Of the remaining 4,176 miles of telephone wires a considerable proportion is required for terminal distribution in connection with the subway system. The removals of wires in 1888 included 714 miles removed by the New York and New Jersey Telephone Company, 20 miles by the Western Union Telegraph Company, and 50 miles by the electric light companies, a total of 784 miles. The telephone companies removed 72 and the other companies 245 poles, a total of 317 poles removed in 1888. Since the Board was organised 335 poles and 1,400 miles of aerial wires have been removed. The actual extension of the system by construction of additional conduits has been 1·58 miles, giving a present aggregate length of conduit of 15·78 miles. The aggregate length of ducts is now 109·78 miles.

Cheltenham.—The adjourned meeting of the Town Council was held on Monday last to take into consideration the report of the Electric Lighting Committee, which gave an approximate estimate of the cost of laying down plant, &c., sufficient for 60 arc lamps of 1,200 candle-power each, and 2,300 incandescent lamps of 16 candle-power each, site and buildings at £11,900, the annual cost of production of which would be £3,300 to £3,700. Mr. Norman, in opening the discussion, pointed out that the Corporation had already affirmed the desirability of the introduction of the light, and that it should be undertaken by the Corporation. Having commented on the advance that had been made in the electric lighting of towns and trade premises, he proceeded to give statistics as to the use of the light in London, Taunton, Bradford, Leamington, and Bath. Bath—once regarded as a sleepy place—was going a-head in the matter, as they were going to have 86 lamps at a cost of £2,000 a year; therefore it must be worth the while of Cheltenham to incur the very small expenditure which the Committee estimated would be necessary if the project were carried out. Mr. Norman said the Committee proposed that tenders should be invited for lighting with arc and incandescent lamps, either or both of which the Council might adopt. The adoption of both systems would yield a profit, the Committee believed, that would largely pay for the lighting of their streets, an income being derivable from the use of the incandescent lamp which would not be obtainable from the arc light alone. After some further observations he moved the adoption of the report. A lengthy discussion followed. The Committee's report was finally adopted by 11 to 4. It empowers the Committee to proceed with the matter, and procure tenders to be submitted to the Council.

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ON THE LOCALISATION OF A PARTIAL-EARTH FAULT IN A SUBMARINE CABLE BY FALL OF THE FAULT'S NATURAL POTENTIAL.

BY HAROLD W. ANSELL AND JULIAN E. YOUNG.

The following modification of the "fall of potential" test for partial-earth faults in submarine cables has been found not only to admit of successful application to practical localisation work, but to possess in certain cases distinct advantages over the ordinary method. A brief account of it may therefore present an interest more than exclusively theoretical to those engaged in such work.

The principle on which it is based consists in the employment of the electromotive force, whether natural or secondary, existing at a partial-earth fault, in place of that of a testing battery. This electromotive force, as is well known, may arise from the simple exposure of the conductor of the cable in sea-water; or, as a secondary effect, from its polarisation by the passage of currents through the fault, as well as from the presence of earth-currents. In general it is due to a combination of the three.

Suggestions have already been made that the natural currents entering a cable at an earth-fault might be utilised for purposes of localisation; but it seems to have been found that they are in general neither of sufficient strength nor constancy for resistance measurements by the bridge methods. Up to the present the general tendency of investigation has been to endeavour to eliminate rather than to utilise such currents, as well as the secondary electromotive force generated by the application of a battery. The potential of these extraneous

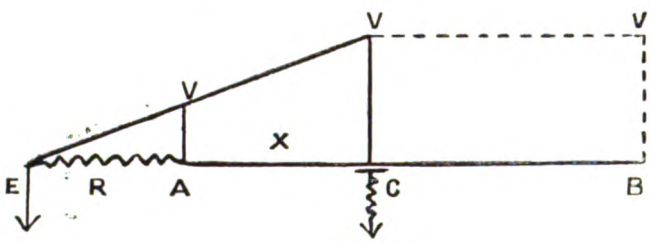

FIG. 1.

currents is, however, in most cases sufficiently high for accurate measurement by means of an electrometer or by condenser discharge through a sensitive galvanometer.

In the following test this potential is applied by means of a method analogous to that described in Kempe's Handbook (4th edition, page 386) to localisation of faults.

The theory of the method is illustrated by Fig. 1, in which A B represents a submarine cable, having a partial-earth fault at C, at a distance x from the end A. R is a resistance inserted between A and earth. The potential of the natural currents entering the cable at C is represented by the vertical V at that point, falling to v at A and to zero at E. Then, by similar triangles, we have

$$x = R\frac{V - v}{v}.$$

The potential V is measured at B, whilst v is observed at A.

When the potentials are sufficiently large the mode of observing them by their permanent deflections through a high resistance is preferable for simplicity of manipulation; but the electrometer or condenser method of measurement may be used should it be required to increase the size of the readings. Simultaneous series of values of V and v must of course be obtained, and the readings at each end taken as rapidly as possible, each station converting the observed potential into terms of some standard of E.M.F., such as Clark's cell.

In practice it will be found that the potentials usually present at exposures give values of V and v sufficiently high for accurate comparison by means of one or other of the foregoing methods. In the case of long cables the earth-currents entering at the exposure would generally furnish the greater part of the potential and determine its sign. The effect of the variations in the earth-current may be minimised by taking the mean of a series of readings of V and v, the absolute values it which do not affect the result. Under certain conditions of might happen that the potentials of the earth and fault currents were equal and opposite, but this seldom lasts for any great length of time. When, however, the natural electromotive force at the fault is found too feeble, the application of a positive current from a battery for a few minutes will generate a secondary electromotive force, which, after removing the battery, furnishes the necessary potential for making the test.

The value of x thus arrived at is evidently independent of the resistance of the exposure, as in the usual "fall of potential" test.

Such a system of measurement may be found in some cases more advantageous than that usually employed from the fact that only two potentials require to be observed, instead of three, that no corrections for earth-currents are necessary, and that the fault is undisturbed by the influence of testing currents during the period of observation. Again, in the case of a cable having an exposure of low resistance, the potential of a battery current falls at the fault to a very low value, in measuring which at the other end of the cable a very small reading will generally be obtained. It is obvious that a small error made in observing this will produce a considerable error in the resulting value of x. When, however, such a fault is itself made to constitute the testing battery, although the

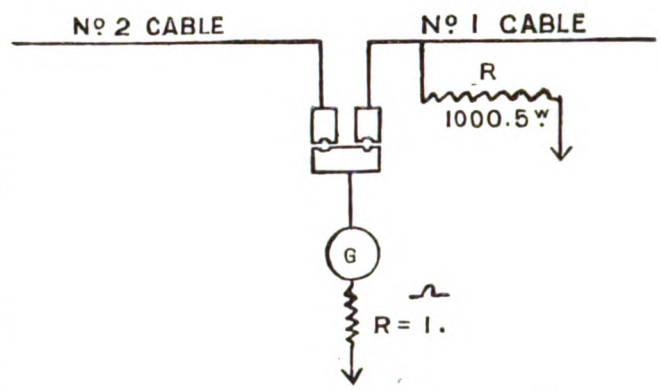

FIG. 2.

resistance of the exposure may be very low, yet the potential at that point is still, within the limits before alluded to, high enough to give a moderately large reading at the end of the cable, in which case a slight error of observation has little influence on the result.

In the following example the foregoing test was applied to the localisation of a fault in one of the cables of the Eastern Telegraph Company, by whose permission it is appended:—

In this case a second cable was looped with that containing the fault, and the two potentials were thus both observed on the same galvanometer, the readings being taken through a resistance of a megohm. A resistance of 1,000·5 ohms was inserted between the end of the faulty cable and earth, and the potential v measured at the junction of the cable with the resistance; whilst the potential V was observed at the end of No. 2 cable. The fault was polarised with a positive current from 20 Leclanchés for three minutes, in order to raise the potentials to a convenient degree; and it was found unnecessary to further increase the deflections by the use of a condenser. After removing the battery, the potentials were found to rise steadily for about five minutes, when they attained a maximum; after which they decreased with unsteadiness. The polarising current was then again applied, and another series taken, the readings being always observed alternately, and as rapidly as possible.

Table A on next page shows one of the series so obtained, from which

$$x = \frac{95 - 33{\cdot}6}{33{\cdot}6} \times 1{,}000{\cdot}5 \text{ ohms.}$$

$$= 1{,}828{\cdot}3 \text{ ohms.}$$

This, in conjunction with a few other readings similarly obtained, gave a mean value of $x = 1{,}820$ ohms. The actual distance of

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the fault, as subsequently ascertained by the repairing steamer, was 1,846 ohms, its minimum resistance being about 100 ohms. The total length of the looped cables was 720 knots, having a resistance of 5,960 ohms.

It may be mentioned that in the ordinary "loop-potential" test, applied to the same fault, the potential at the exposure fell to a value of 0·085 of that of the battery, an inconveniently small proportion.

Table A.—Scale Divisions.

V.	*v.*	
48	16	
63	20	
76	27	
85	31	
95	34	
108	38	
118	42	
127	46	
134	48	(maxima)
mean 95	33·6	

THE DISCHARGE OF A LEYDEN JAR.*

It is one of the great generalisations established by Faraday, that all electrical charge and discharge is essentially the charge and discharge of a Leyden jar. It is impossible to charge one body alone. Whenever a body is charged positively, some other body is *ipso facto* charged negatively, and the two equal opposite charges are connected by lines of induction. The charges are, in fact, simply the ends of these lines, and it is as impossible to have one charge without its correlative as it is to have one end of a piece of string without there being somewhere, hidden it may be, split up into strands it may be, but somewhere existent, the other end of that string.

This I suppose familiar fact that all charge is virtually that of a Leyden jar being premised, our subject for this evening is at once seen to be a very wide one, ranging, in fact, over the whole domain of electricity. For the charge of a Leyden jar includes virtually the domain of electrostatics; while the discharge of a jar, since it constitutes a current, covers the ground of current electricity all except that portion which deals with phenomena peculiar to steady currents. And since a current of electricity necessarily magnetises the space around it, whether it flows in a straight or in a curved path, whether it flow through wire or burst through air, the territory of magnetism is likewise invaded; and inasmuch as a Leyden jar discharge is oscillatory, and we now know the vibratory motion called light to be really an oscillating electric current, the domain of optics is seriously encroached upon.

But though the subject I have chosen would permit this wide range, and though it is highly desirable to keep before our minds the wide-reaching import of the most simple-seeming fact in connection with such a subject, yet to-night I do not intend to avail myself of any such latitude, but to keep as closely and distinctly as possible to the Leyden jar in its homely and well-known form, as constructed out of a glass bottle, two sheets of tinfoil and some stickphast.

The act of charging such a jar I have permitted myself now for some time to illustrate by the mechanical analogy of an inextensible endless cord able to circulate over pulleys, and threading in some portion of its length a row of tightly-gripping beads which are connected to fixed beams by elastic threads.

The cord is to represent electricity; the beads represent successive strata in the thickness of the glass of the jar, or, if you like, atoms of dielectric or insulating matter. Extra tension in the cord represents negative potential, while a less tension (the nearest analogue to pressure adapted to the circumstances) represents positive potential. Forces applied to move the cord, such as winches or weights, are electromotive forces; a clamp or fixed obstruction represents a rheostat or contact-breaker; and an excess or defect of cord between two strata of matter represents a positive or a negative charge.

The act of charging a jar is now quite easily depicted, as shown in the diagram on next column.

To discharge the jar one must remove the charging E.M.F. and unclamp the screw, *i.e.*, close the circuit. The stress in the elastic threads will then rapidly drive the cord back, the inertia of the beads will cause it to overshoot the mark, and for an instant the jar will possess an inverse charge. Back again the cord swings, however, and a charge of same sign as at first, but of rather less magnitude, would be found in the jar if the operation were now suspended. If it be allowed to go on, the oscillations gradually subside, and in a short time everything is quiescent, and the jar is completely discharged.

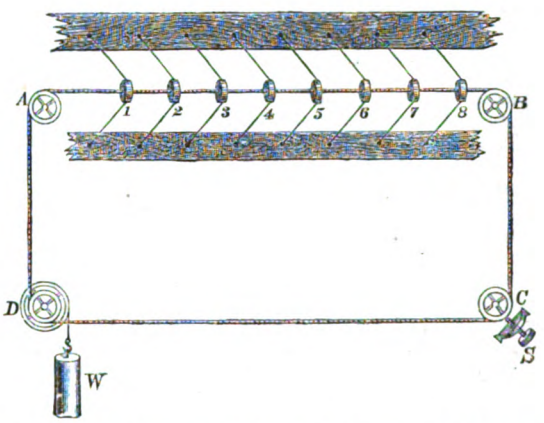
All this occurs in the Leyden jar, and the whole series of oscillations, accompanied by periodic reversal and re-reversal of the charges of the jar, is all accomplished in the incredibly short space of time occupied by a spark.

Consider now what the rate of oscillation depends on. Manifestly on the elasticity of the threads and on the inertia of the matter which is moved. Take the simplest mechanical analogy, that of the vibration of a loaded spring, like the reeds in a musical box. The stiffer the spring, and the less the load, the faster it vibrates. Give a mathematician these data, and he will calculate for you the time the spring takes to execute one complete vibration, the "period" of its swing. [Loaded lath in vice.]

The electrical problem and the electrical solution are precisely the same. That which corresponds to the flexibility of the spring is in electrical language called static capacity, or, by Mr. Heaviside, permittance. That which corresponds to the inertia of ordinary matter is called electro-magnetic inertia, or self-induction, or, by Mr. Heaviside, inductance.

Increase either of these, and the rate of oscillation is diminished. Increasing the static capacity corresponds to lengthening the spring; increasing the self-induction corresponds to loading it.

Now the static capacity is increased simply by using a larger jar, or by combining a number of jars into a battery in the very old-established way. Increase in the self-induction is attained by giving the discharge more space to magnetise, or by making it magnetise a given space more strongly. For electro-magnetic



Mechanical analogy of a circuit partly *dielectric*: for instance, of a charged condenser. A is its positive coat, B its negative, C D pull ys, W weight, S set screw.

inertia is wholly due to the magnetisation of the space surrounding a current, and this space may be increased or its magnetisation intensified as much as we please.

To increase the space we have only to make the discharge take a long circuit instead of a short one. Thus, we may send it by a wire all round the room, or by a telegraph wire all round a town, and all the space inside it and some of that outside will be more or less magnetised. More or less, I say; and it is a case of less rather than more. Practically very little effect is felt except close to the conductor, and accordingly the self-induction increases very nearly proportionally to the length of the wire, and not in proportion to the area enclosed, provided the going and return wires are kept a reasonable distance apart, so as not to encroach upon each other's appreciably magnetised regions.

But it is just as effective, and more compact, to intensify the magnetisation of a given space by sending the current hundreds of times round it instead of only once; and this is done by inserting a coil of wire into the discharge circuit.

Yet a third way there is of increasing the magnetisation of a given space, and that is to fill it with some very magnetisable substance, such as iron. This, indeed, is a most powerful method under many circumstances, it being possible to increase the magnetisation, and therefore the self-induction or inertia of the current, some 5,000 times by the use of iron.

But in the case of the discharge of a Leyden jar iron is of no advantage. The current oscillates so quickly that any iron introduced into its circuit, however subdivided into thin wires it may be, is protected from magnetism by inverse currents induced in its outer skin, as your Professor of Natural Philosophy* has shown, and

* Friday evening discourse at the Royal Institution of Great Britain, on March 8, by Prof. Oliver Lodge, F.R.S. We are indebted to the Editor of *Nature* for advanced proofs of this Lecture.

* Lord Rayleigh

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accordingly it does not get magnetised ; and so far from increasing the inductance of the discharge circuit it positively diminishes it by the reaction effect of these induced currents ; it acts, in fact, much as a similar mass of tin might be expected to do.

The conditions determining rate of oscillation being understood we have next to consider what regulates the damping out of the vibrations, *i.e.*, the total duration of the discharge.

Resistance is one thing. To check the oscillations of a vibrating spring you apply to it friction, or make it move in a viscous medium, and its vibrations are speedily damped out. The friction may be made so great that oscillations are entirely prevented, the motion being a mere dead-beat return to the position of equilibrium ; or, again, it may be greater still, and the motion may correspond to a mere leak or slow sliding back, taking hours or days for its accomplishment. With very large condensers, such as are used in telegraphy, this kind of discharge is frequent, but in the case of a Leyden jar discharge it is entirely exceptional. It can be caused by including in the circuit a wet string, or a capillary tube full of distilled water, or a slab of wood, or other atrociously bad conductor of that sort ; but the conditions ordinarily associated with the discharge of a Leyden jar, whether it discharge through a long or a short wire, or simply through its tongs, or whether it overflow its edge or puncture its glass, are such as correspond to oscillations, and not to leak. [Discharge jar through capillary water tube.]

When the jar is made to leak through wood or water the discharge is found to be still not steady : it is not oscillatory, indeed, but it is intermittent. It occurs in a series of little jerks, as when a thing is made to slide over a resined surface. The reason of this is that the terminals discharge faster than the circuit can supply the electricity, and so the flow is continually stopped and begun again.

Such a discharge as this, consisting really of a succession of small sparks, may readily appeal to the eye as a single flash, but it lacks the noise and violence of the ordinary discharge ; and any kind of moving mirror will easily analyse it into its constituents and show it to be intermittent. [Look at sparks waggling head or opera-glass.]

It is pretty safe to say, then, that whenever a jar discharge is not oscillatory it is intermittent, and when not intermittent is oscillatory. There is an intermediate case when it is really dead beat, but it could only be hit upon with special care, while its occurrence by accident must be rare.

So far I have only mentioned resistance or friction as the cause of the dying out of the vibrations ; but there is another cause, and that a most exciting one.

The vibrations of a reed are damped partly indeed by friction and imperfect elasticity, but partly also by the energy transferred to the surrounding medium and consumed in the production of sound. It is the formation and propagation of sound-waves which largely damp out the vibrations of any musical instrument. So it is also in electricity. The oscillatory discharge of a Leyden jar disturbs the medium surrounding it, carves it into waves which travel away from it into space : travel with a velocity of 185,000 miles a second : travel precisely with the velocity of light. [Tuning fork.]

The second cause, then, which damps out the oscillations in a discharge circuit is *radiation—electrical* radiation, if you like so to distinguish it, but it differs in no respect from ordinary radiation (or "radiant heat," as it has so often been called in this place), it differs in no respect from Light except in the physiological fact that the retinal mechanism, whatever it may be, responds only to waves of a particular, and that a very small, size, while radiation in general may have waves which range from 10,000 miles to a millionth of an inch in length.

The seeds of this great discovery of the nature of light were sown in this place ; it is all the outcome of Faraday's magneto-electric and electrostatic induction ; the development of them into a rich and full-blown theory was the greatest part of the life-work of Clerk-Maxwell ; the harvest of experimental verification is now being reaped by a German ; but by no ordinary German. Dr. Hertz, now Professor in the Polytechnicum of Karlsruhe, is a young investigator of the highest type. Trained in the school of Helmholtz, and endowed with both mathematical knowledge and great experimental skill, he has immortalised himself by a brilliant series of investigations which have cut right into the ripe corn of scientific opinion in these islands, and by the same strokes as have harvested the grain have opened up wide and many branching avenues to other investigators.

At one time I had thought of addressing you this evening on the subject of these researches of Hertz, but the experiments are not yet reproducible on a scale suited to a large audience, and I have been so closely occupied with some not wholly dissimilar, but independently-conducted, researches of my own—researches led up to through the unlikely avenue of lightning conductors—that I have had as yet no time to do more than verify some of them for my own edification.

In this work of repetition and verification Prof. Fitzgerald has, as related in a recent number of *Nature*, probably gone further ; and if I may venture a suggestion to your hon. secretary, I feel sure that a discourse on Hertz's researches from Prof. Fitzgerald next year would be not only acceptable to you, but would be highly conducive to the progress of science.

I have wandered a little from my Leyden jar, and I must return to it and its oscillations. Let me very briefly run over the history of our knowledge of the oscillatory character of a Leyden jar discharge. It was first clearly realised and distinctly stated by that excellent experimentalist, Joseph Henry, of Washington, a man not wholly unlike Faraday in his mode of work though doubtless possessing to a less degree that astonishing insight into intricate and obscure phenomena ; wanting also in Faraday's circumstantial advantages.

This great man arrived at a conviction that the Leyden jar discharge was oscillatory by studying the singular phenomena attending the magnetisation of steel needles by a Leyden jar discharge, first observed in 1824 by Savary. Fine needles, when taken out of the magnetising helices, were found to be not always magnetised in the right direction, and the subject is referred to in German books as anomalous magnetisation. It is not the magnetisation which is anomalous, but the currents which have no simple direction ; and we find in a memoir published by Henry, in 1842, the following words :—

"This anomaly, which has remained so long unexplained, and which, at first sight, appears at variance with all our theoretical ideas of the connection of electricity and magnetism, was, after considerable study, satisfactorily referred by the author to an action of the discharge of the Leyden jar which had never before been recognised. The discharge, whatever may be its nature, is not correctly represented (employing for simplicity the theory of Franklin) by the single transfer of an imponderable fluid from one side of the jar to the other ; the phenomenon requires us to admit *the existence of a principal discharge in one direction and then several reflex actions backward and forward, each more feeble than the preceding, until the equilibrium is obtained.* All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena, which are to be found in the older works on electricity, but which have until this time remained unexplained."*

The italics are Henry's. Now if this were an isolated passage it might be nothing more than a lucky guess. But it is not. The conclusion is one at which he arrives after a laborious repetition and serious study of the facts, and he keeps the idea constantly before him when once grasped, and uses it in all the rest of his researches on the subject. The facts studied by Henry do, in my opinion, support his conclusion, and if I am right in this it follows that he is the original discoverer of the oscillatory character of a spark, although he does not attempt to state its theory. That was first done, and completely done, except as regards radiation loss of energy, in 1853, by Sir William Thomson ; and the progress of experiment by Feddersen, Helmholtz, Schiller and others, has done nothing but substantiate it.

The writings of Henry have been only quite recently collected and published by the Smithsonian Institution of Washington in accessible form, and accordingly they have been far too much ignored. The two volumes contain a wealth of beautiful experiments clearly recorded, and well repay perusal.

The discovery of the oscillatory character of a Leyden jar discharge may seem a small matter, but it is not. One has only to recall the fact that the oscillators of Hertz are essentially Leyden jars—one has only to use the phrase "electro-magnetic theory of light" to have some of the momentous issues of this discovery flash before one.

One more extract I must make from that same memoir by Henry,† and it is a most interesting one ; it shows how near he was, or might have been, to obtaining some of the results of Hertz, though, if he had obtained them, neither he nor any other experimentalist could possibly have divined their real significance.

It is, after all, the genius of Maxwell and of a few other great theoretical physicists whose names are on everyone's lips‡ which endows the simple induction experiments of Hertz and others with such stupendous importance.

Here is the quotation :—

"In extending the researches relative to this part of the investigations, a remarkable result was obtained in regard to the distance at which induction effects are produced by a very small quantity of electricity ; a single spark from the prime conductor of a

* "Scientific Writings of Joseph Henry," Vol. I., p. 201. Published by the Smithsonian Institution, Washington, 1886.

† *Loc. cit.*, p. 204.

‡ And of one whose name is not yet on everybody's lips, but whose profound researches into electro-magnetic waves have penetrated further than anybody yet understands into the depths of the subject, and whose Papers have very likely contributed largely to the theoretical inspiration of Hertz, I mean that powerful mathematical physicist, Mr. Oliver Heaviside.

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machine, of about an inch long, thrown on to the end of a circuit of wire in an upper room, produced an induction sufficiently powerful to magnetise needles in a parallel circuit of wire placed in the cellar beneath, at a perpendicular distance 30 feet, with two floors and ceilings, each 14 inches thick, intervening. The author is disposed to adopt the hypothesis of an electrical *plenum* [in other words, of an ether], and from the foregoing experiment it would appear that a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000 feet of capacity; and when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

Comparable it is, indeed, for we now know it to be the self-same process.

One immediate consequence and easy proof of the oscillatory character of a Leyden jar discharge is the occurrence of phenomena of sympathetic resonance.

Everyone knows that one tuning fork can excite another at a reasonable distance if both are tuned to the same note. Everyone knows, also, that a fork can throw a stretched string attached to it into sympathetic vibration if the two are tuned to unison or to some simple harmonic. Both these facts have their electrical analogue. I have not time to go fully into the matter to-night, but I may just mention the two cases which I have myself specially noticed.

A Leyden jar discharge can so excite a similarly-timed neighbouring Leyden jar circuit as to cause the latter to burst its dielectric if thin and weak enough. The well-timed impulses accumulate in the neighbouring circuit till they break through a quite perceptible thickness of air. Put the circuits out of unison by varying the capacity or by including a longer wire in one of them; then, although the added wire be a coil of several turns, well adapted to assist mutual induction as ordinarily understood, the effect will no longer occur.

That is one case, and it is the electrical analogue of one tuning-fork exciting another. It is too small at present to show here satisfactorily, for I only recently observed it, but it is exhibited in the library at the back.

The other case, analogous to the excitation of a stretched string of proper length by a tuning fork, I published last year under the name of the experiment of the recoil kick, where a Leyden jar circuit sends waves along a wire connected by one end with it, which waves splash off at the far end with an electric brush or long spark.

I will show merely one phase of it to-night, and that is the reaction of the impulse accumulated in the wire upon the jar itself, causing it to either overflow or burst. [Sparks of gallon or pint jar made to overflow by wire round room.]*

The early observations by Franklin on the bursting of Leyden jars, and the extraordinary complexity or multiplicity of the fracture that often results, are most interesting.

His electric experiments, as well as Henry's, well repay perusal, though of course they belong to the infancy of the subject.

He notes the striking fact that the bursting of a jar is an extra occurrence; it does not replace the ordinary discharge in the proper place, it accompanies it; and we now know that it is precipitated by it, that the spark occurring properly between the knobs sets up such violent surgings that the jar is far more violently strained than by the static charge or mere difference of potentials between its coatings; and if the surgings are at all even roughly properly timed, the jar is bound to either overflow or burst.

Hence a jar should always be made without a lid, and with a lip protruding a carefully considered distance above its coatings; not so far as to fail to act as a safety valve, but far enough to prevent overflow under ordinary and easy circumstances.

And now we come to what is after all the main subject of my discourse this evening, viz., the optical and audible demonstration of the oscillations occurring in the Leyden jar spark. Such a demonstration has, so far as I know, never before been attempted, but if nothing goes wrong we shall easily accomplish it.

And first I will do it audibly. To this end the oscillations must be brought down from their extraordinary frequency of a million or hundred thousand a second to a rate within the limits of human audition. One does it exactly as in the case of the spring—one first increases the flexibility and then one loads it. [Spark from battery of jars and varying sound of same.]

Using the largest battery of jars at our disposal, I take the spark between these two knobs—not a long spark, ¼in. will be quite sufficient. Notwithstanding the great capacity, the rate of vibration is still far above the limit of audibility, and nothing but the customary crack is heard. I next add inertia to the circuit by including a great coil of wire, and at once the spark changes character, becoming a very shrill but an unmistakable whistle, of a quality approximating to the cry of a bat. Add another coil, and down comes the pace once more, to something like 5,000 per second, or about the highest note of a piano. Again and again I load the circuit with magnetisability, and at last the spark has only 500 vibrations a second, giving the octave above the middle C.

One sees clearly why one gets a musical note: the noise of the spark is due to a sudden heating of the air; now if the heat is oscillatory, the sound will be oscillatory too, but both will be an octave above the electric oscillation, if I may so express it, because two heat-pulses will accompany every complete electric vibration, the heat production being independent of direction of current.

Having thus got the frequency of oscillation down to so manageable a value, the optical analysis of it presents no difficulty: a simple looking-glass waggled in the hand will suffice to spread out the spark into a serrated band, just as can be done with a singing or a sensitive flame, a band, too, of very much the same appearance.

Using an ordinary four-square rotating mirror driven electromagnetically at the rate of some two or three revolutions per second, the band is at the lowest pitch seen to be quite coarsely serrated; and fine serrations can be seen with four revolutions per second in even the shrill whistling sparks.

The only difficulty in seeing these effects is to catch them at the right moment. They are only visible for a minute fraction of a revolution, though the band may appear drawn out to some length. The further away a spark is from the mirror, the more drawn out it is, but also the less chance there is of catching it.

With a single observer it is easy to arrange a contact maker on the axle of the mirror which shall bring on the discharge at the right place in the revolution, and the observer may then conveniently watch for the image in a telescope or opera-glass, though at the lower pitches nothing of the kind is necessary.

But to show it to a large audience various plans can be adopted. One is to arrange for several sparks instead of one; another is to multiply images of a single spark by suitably adjusted reflectors, which if they are concave will give magnified images; another is to use several rotating mirrors; and, indeed, I do use two, one adjusted so as to suit the spectators in the gallery.

But the best plan that has struck me is to combine an intermittent and an oscillatory discharge. Have the circuit in two branches, one of high resistance so as to give intermittences, the other of ordinary resistance so as to be oscillatory, and let the mirror analyse every constituent of the intermittent discharge into a serrated band. There will thus be not one spark, but a multitude of successive sparks, close enough together to sound almost like one, separate enough in the rotating mirror to be visible on all sides at once, and each one analysed into a serrated band.

But to achieve it one must have great exciting power. In spite of the power of this magnificent Wimshurst machine, it takes some time to charge up our great Leyden battery, and it is tedious waiting for each spark. For a single observer it does excellently; for a number of observers one wants an instrument which shall charge the battery not once only, but many times over, with overflows between, and all in the twinkling of an eye.

To get this I must abandon my friend Mr. Wimshurst, and return to Michael Faraday. In front of the table is a great induction coil; its secondary has the resistance needed to give an intermittent discharge. The quantity it supplies at a single spark will fill our jar to overflowing several times over. [Excite jars by coil.]

Running over the gamut with this coil now used as our exciter instead of the Wimshurst machine—everything else remaining exactly as it was—you hear the sparks give the same notes as before, but with a slight rattle in addition, indicating intermittence as well as alternation. Rotate the mirror, and every one should see one or other of the serrated bands of light at nearly every break of the primary current of the coil. [Rotating mirror to analyse sparks.]

The musical sparks which I have now shown you were obtained by me during a special digression* for the purpose while examining the effect of discharging a Leyden jar round heavy glass or bisulphide of carbon. The rotation of the plane of polarisation of light by a steady current, or by a magnetic field of any kind properly disposed with respect to the rays of light, is a very familiar one in

* During this experiment the audience observed the gilding of the paper brightly sparkling on the walls of the room. It was probably the primary result of the absorption of the electric waves. When light falls on metal it excites electric currents and is reflected. The large waves of electric radiation with which the room was full during the discharge of the jar excited visible electric currents in the act of being reflected by the gilt walls. It is the same kind of thing as in other forms I have often noticed in connection with lighting conductor experiments, and is only another illustration of the danger attending the best conductors as ordinarily arranged. It was this kind of splashing or surging of electricity which recently set on fire the Hotel de Ville at Brussels, so elaborately and exceptionally well protected by M. Melsens. This suggested explanation is merely tentative and temporary. I have had no time to investigate the matter locally.

* A conversation with Sir W. Thomson at Christmas had probably something to do with my seeing the interest of getting slow oscillations. My chief attention has been directed to quick oscillations.

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this place. Perhaps it is known also that it can be done by a Leyden jar current. But I do not think it is; and the fact seems to me very interesting. It is not exactly new—in fact, as things go now it may be almost called old, for it was investigated six or seven years ago by two most highly skilled French experimenters, Messrs. Bichat and Blondlot.

But it is exceedingly interesting as showing how short a time, how absolutely no time is needed by heavy glass to throw itself into the suitable rotatory condition. Some observers have thought they had proved that heavy glass requires time to develop the effect, by spinning it between the poles of a magnet and seeing the effect decrease; but their conclusions cannot be right, for the polarised light follows every oscillation in the discharge, the plane of polarisation being waved to and fro as often as 70,000 times a second in my own observation.

Very few persons in the world have seen the effect. In fact, I doubt if anyone had seen it a month ago except Messrs. Bichat and Blondlot. But I hope to make it visible to most persons here, though I hardly hope to make it visible to all.

Returning to the Wimshurst machine as exciter, I pass a discharge round the spiral of wire inclosing this long tube of CS_2, and the analysing Nicol being turned to darkness, there may be seen a faint—by those close to not so faint, but a very momentary—restoration of light on the screen at every spark. [CS_2 tube experiment on screen.]

Now I say that this light restoration is also oscillatory. One way of proving this fact is to insert a bi-quartz between the Nicols. With a steady current it constitutes a sensitive detector of rotation, its sensitive tint turning green on one side and red on the other. But with this oscillatory current a bi-quartz does absolutely nothing. [Bi-quartz.]

That is one proof. Another is that rotating the analyser either way weakens the extra brightening of the field, and weakens it equally either way.

But the most convincing proof is to reflect the light coming through the tube upon our rotating mirror, and to look now not at the spark, or not only at the spark, but at the faint band into which the last residue of light coming through polariser and tube and analyser is drawn out. [Analyse the light in rotating mirror.]

At every discharge this faint streak brightens in places into a beaded band: these are the oscillations of the polarised light; and when examined side by side they are as absolutely synchronous with the oscillations of the spark itself as can be perceived.

Out of a multitude of phenomena connected with the Leyden jar discharge I have selected a few only to present to you here this evening. Many more might have been shown, and great numbers more are not at present adapted for presentation to an audience, being only visible with difficulty and close to.

An old and trite subject is seen to have in the light of theory an unexpected charm and brilliancy. So it is with a great number of other old familiar facts at the present time.

The present is an epoch of astounding activity in physical science. Progress is a thing of months and weeks, almost of days. The long line of isolated ripples of past discovery seem blending into a mighty wave, on the crest of which one begins to discern some oncoming magnificent generalisation. The suspense is becoming feverish, at times almost painful. One feels like a boy who has been long strumming on the silent key-board of a deserted organ, into the chest of which an unseen power begins to blow a vivifying breath. Astonished, he now finds that the touch of a finger elicits a responsive note, and he hesitates, half delighted, half affrighted, lest he be deafened by the chords which it would seem he can now summon forth almost at will.

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

An arc lamp being an apparatus for transforming the electric energy supplied to it through the conducting wires into heat and light, it obviously cannot be expected to give a steady illumination unless it can be so arranged and operated that, in the first place, the rate at which it appropriates and transforms the electric energy is constant; and that, in the second place, the circumstances attending this transformation (in respect of the triple relation between the quantity of heat evolved, the degree of temperature, and the emissivity of the incandescent surface) also remain constant. The first of these two provisos relates to the operation of the system of lamps and dynamos (or other means of electric supply) acting conjointly; the second of them relates solely to the quality of the carbon pencils used as electrodes.

As the latter is a simple matter, it may be disposed of first. Suppose the pencils to be composed of a homogeneous carbon, the physical properties of which, such as hardness, specific thermal capacity, conductivity for electricity, conductivity for heat, emissivity, &c., are constant; also that they are cylindrical and of given diameter. Then it follows that if energy is being expended at a uniform rate in heating the tips of a pencil it will be maintained at a uniform temperature, and the amount of light emitted per square millimetre of the surface will be constant, and, as the section is constant, the rate of consumption constant, and the pencil homogeneous, the form once acquired by the incandescent tip (whether positive crater or negative peak) will remain constant. It may be remarked, in passing, that the researches of Capt. Abney have shown that the white light of the incandescent carbon surface of the crater at the positive pole of the arc is always of precisely the same composition in respect of the relative proportions of waves of different colours. This most important observation indicates beyond doubt that the temperature of the actual light-emitting surface is always the same. Indeed, this ought to be the case if the latent heat of vapourisation of carbon be a positive quantity. When the surface attains this temperature volatilisation begins; and when so begun the temperature cannot rise further, any more than ice can be raised above its temperature of fusion. The limiting temperature of the voltaic arc is the temperature of volatilisation of the material of the electrodes. This is, in itself, a reason why the introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower its intrinsic brilliancy; for all known elements have a lower temperature of volatilisation, and all compounds are dissociated at arc temperatures.

If, then, we may assume homogeneity of the carbons to be used the steadiness of the arc light will depend solely upon the maintenance of a steady rate of appropriating and transforming electric energy. How a want of homogeneity may be compensated for in the actual working of the lamp is a point reserved for consideration later.

The rate at which electric energy is appropriated from the wires, and transformed in the lamp into heat and light, always depends both upon the construction of the lamp and upon the conditions imposed upon the system of electric supply. This is a mere consequence of the fact, well known to every electric engineer, that the amount of electric energy per second appropriated by any electric device, motor, or accumulator, is itself the product of two quantities—the current, and the pressure (or potential) at which the current is supplied. To put the matter in electrician's language, the number of *watts* of electric energy per second appropriated by the lamp* is equal to the number of *amperes* that flow through

* Paper read before the Society of Arts on March 6. 1889.

* Strictly speaking, the actual number of *watts* utilised in the arc is somewhat less than the whole number received from the supply, as a portion of the energy is expended in passing the current through the regulating coils, and another portion is lost in consequence of the resistance offered by the pencils of carbon themselves, and is merely expended in warming them. We may calculate the former loss as follows:—Let E represent the whole number of volts from terminal to terminal, and let i represent the whole current supplied, then the whole number of watts supplied is Ei. Let the *ohms* of resistance of the regulating coils in the main circuit be called a, and that of the shunt coils be called b, that of the carbon pencils themselves c, and that of the resistance coils sometimes used in the main circuit to steady the arc r. Also, in the case where the lamp has a shunt circuit, let the portion of i which passes through the carbons be called i_1, and that which goes through the shunt i_2; so that $i_1 + i_2 = i$. The losses are then as follows:—

ai_1^2 = watts lost in main-circuit coil;
bi_2^2 = $E^2 \div b$ = watts lost in shunt coil;
ci_1^2 = watts lost in warming carbon pencil;
ri^2 = watts lost in the resistance coil.

The resistance of carbon pencils is usually small, and may be materially reduced by a thin coating of copper. The carbons used in commerce (11 to 15 millimetres in diameter) vary from about 0·15 to 0·2 ohms per foot, if plain, and from 0·001 to 0·09 if coppered. Cored carbons have a higher resistance than uncored. Carbons cut from solid gas coke have from five to twenty times as much resistance as those made by the usual modern processes. When lamps are run in series, the resistance offered by the pencils is of more importance; for example, a set of 50 lamps newly trimmed with long carbons may offer 25 ohms more resistance than when all the carbons have burned down short. The resistance, a, of the regulating coils that are in the main circuit differs in different lamps, but may be taken at from 0·05 to 0·2 ohms. The resistance, b, of the shunt coils is seldom less than 200 ohms, and may be as much as from 400 to 500 ohms. Of the volts, E, applied to the lamp only a part is utilised, the lost volts being accounted for by the resistances in the path of the current. If these are deducted from the applied electromotive force, there will remain a certain number of volts, which we may call e, which are available as a useful difference of potential at the arc itself. To measure e directly, one has only to apply a voltmeter, making the contacts of its two leading wires to the two carbons at points respectively just above and just below the incandescent tips. The watts actually utilised in the arc are then calculated as the product ei_1. As shown above, e is less than E, and, indeed, may be considerably less, the lost volts depending upon the resistances introduced, and on the current flowing through them. If E is constant, e will not necessarily be so, but will be very nearly if i is also constant. Also i_1 is less than i in all lamps that have a shunt regulating coil, but is not usually more than from 3 to 5 per cent. less than i, so that in the cases where i is kept constant, i_1 will be nearly so also.

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it multiplied by the number of *volts* that may be applied as a difference of potentials between its two terminals. To keep constant the *product* of the amperes and the volts is the practical problem which the mechanism of the arc lamp must be designed to solve.

A point of much theoretical interest, and in reality of great practical importance, is the fact, long disputed, now established beyond question, that the arc itself does not act simply as an added resistance in the path of the current, but exercises also a counter-electromotive force, and tends to set up an opposing current. The apparent resistance of the arc resembles that of an electrolytic cell, or that of an electric motor when running, or, that of a thermopile when a current from an external source is passed through it. The current which flows through the arc arouses, by a species of polarisation, an opposing electromotive force. The simplest fact in proof of this is that, unlike any ordinary conductor, the apparent resistance of the arc is not proportional to its length. The apparent resistance of an arc two millimetres in length between the carbon tips is not double that of an arc one millimetre in length, nor anything near double. The fairest way to investigate the matter is to make a series of experiments with arcs of different lengths, the current being independently so regulated as to be maintained of the same strength in each case. There appears to be a true resistance proportional to the length, and a back-electromotive force which in steady arcs, and with currents of from seven to fifteen amperes, appears to be about 38 to 39 volts. When the arc hisses, as often happens if the length of it be very short, the back-electromotive force fluctuates very much, but always drops to something under 20 volts. Except in the case of constant-current circuits, this causes a sudden increase of current when the lamp begins to hiss, and it may be noticed that the light, though unsteady during hissing, is brighter at the negative pole of the arc.

Hitherto all guesses as to the cause of this counter-electromotive force have been very vague, not to say wild. To account for thirty-nine volts of polarisation on any hypothesis that it is due to electrolytic or thermo-electric action, is to suggest causes which are, to say the least, wholly inadequate. The explanation which for the past two years I have been in the habit of suggesting to my students, and which has not been otherwise published hitherto, is as follows:—Every reversible phenomenon which the current can itself produce, and which requires an expenditure of energy for its production, necessarily implies the exhibition of a counter-electromotive force. One has only to look at the cases of the reversible chemical action in a cell, of the reversible magneto-mechanical action of a motor, the reversible heating effects of a thermo-electric junction, to comprehend this. Now the phenomenon of volatilisation is a reversible one; give to the solid carbon at its volatilisation-temperature the necessary latent heat, it is changed to vapour; take from the vapour its latent heat, it condenses back to solid carbon. The arc under normal circumstances is the seat of an actual evaporation of carbon at the positive pole, as well as of a combustion at both poles. So far as any data exist, it appears that the excess of carbon consumed at the positive pole by an ordinary continuous current is about 0·5 grammes per ampere hour. If we knew the latent heat of volatilisation of carbon per gramme we could calculate *à priori* the necessary minimum electromotive force at the positive pole, which would obviously represent the counter-electromotive force so far as it is situated at that point. With long arcs the excess of consumption of the positive pencil over that of the negative is both less and more regular than that which occurs with short arcs. With short arcs three other phenomena occur which are important in this connection. Firstly, the short arc is liable to whistle or hiss, giving evidence of instability; secondly, it frequently gives rise to "mushrooms," or irregular growths of carbon upon the apex of the negative pencil; thirdly, when it hisses the counter-electromotive force becomes very unsteady, but appears to have an average value about half that of the steady long arc. It is worth while to throw out the suggestion that the condensation of carbon at the negative pole, in the short arc is accountable for the change in electromotive force, and for the instability which manifests itself by the hissing sound.

Passing from these conjectures to the construction of lamps for the production of light by the arc, we are now prepared to lay down the points which must be provided for in every arc lamp. It must be emphatically pointed out at the outset that, as the performance of a lamp depends upon the conditions under which it is supplied with electric energy by the circuit, the design of the lamp necessarily also depends on those conditions. In the present state of the art of electric distribution we may classify the conditions of electric supply under the following heads:—

I.—Continuous Supply at Constant Potential.

In this case the arc lamps are arranged either simply all in parallel or in parallels containing two in series, the currents being divided by mains and branches to the lamps. At least 55 volts should be allowed between the mains for single arcs. Practice shows that arc lamps in parallel burn more steadily if a resistance wire of ·25 to 1·0 ohm be included in the lamp circuit. Taking the back electromotive force of a steady arc at 39 volts, it is obvious that the excess of the volts at the mains over this represents the volts used in driving the current through the actual resistance in the main circuit of the lamp. This resistance consists of four parts—the true resistance of the arc itself, which may vary from $\frac{1}{10}$ to $\frac{1}{2}$ ohm; the resistance of the carbon pencils, which averages about 0·15 ohm per foot per plain carbons; the resistance of the main-circuit coils, which varies in different lamps from 0·05 to 0·2 ohm; and the resistance of the wire introduced for steadying the lamp. In a 10-ampere lamp, working at 55 volts at the mains, 16 volts remain, after deducting 39 for the back electromotive force, and these 16 are approximately distributed as follows:—2 volts in the arc itself, 3 volts in the carbons (say 2ft. long in the total), 1 volt in the main coil, and 10 volts in the steadying resistance.

II.—Continuous Supply with Constant Current.

In this case the arc lamps arranged in series, the whole of the current going from one lamp to the next, and returning to the dynamo after having traversed successively all the lamps. This is, *par excellence*, the arc light system of distribution, the parallel system at constant potential requiring heavier mains. As the lamps arranged in series tend to steady one another, it is not necessary to allow more than 45 to 50 volts per lamp, including the ordinary lengths of cable from lamp to lamp. From 5 to 10 amperes is the usual current for arc lamps in series.

III.—Alternating Supply at Constant Potential.

In this case also the lamps are usually arranged as in the first case, the only difference being in certain structural details, such as lamination of iron cores.

IV.—Alternating Supply with Constant Current.

This case can hardly be said to be practical, though alternate-current dynamos, capable of supplying 6 or 8 lamps in series, have been constructed in past years.

The supply systems, whether continuous or alternating, must be assumed, for the purpose of this Paper, to perform efficiently what they profess, namely, to maintain constant one of the two factors of the electric power which they supply to the distributing system. In each case it remains for the mechanism of the lamp to effect such adjustment as will maintain constant the other factor of the product. If the condition of supply is at constant potential, then it is for the lamp itself so to adjust its carbons as to keep the current through the arc constant. If the condition of supply is with constant current, then the lamp must adjust it carbons to maintain between them the requisite potential. Hence the differences which are necessary in construction between those lamps which are to work at constant potential and those which are to work with constant current. These differences, as will now be shown, chiefly affect the feeding mechanisms of the lamp.

In discussing the necessary mechanisms of arc lamps, no further reference will be made to lamps of the Jablochkoff candle type, nor to those with abutment blocks of marble ("Sun" lamp, &c.), nor to the so-called incandescence-arc ("Semi-incandescent") lamps, nor to those with curved carbons (Heinrichs's type), nor yet to those horizontal carbons (De Mersenne's, Solignac's, &c.).

Necessary Mechanism of Arc Lamps.

[A]. *Driving Power.*—In every lamp some means or mechanism is required to propel the carbons toward one another as they burn away, gravity being by far the most common agency for doing this.

[B.] *Striking Mechanism.*—In every arc lamp it is requisite to provide a mechanism for bringing the tips of the carbon pencils into contact, and then parting them asunder to the requisite distance across which the arc or flame plays. If, as in most lamps, the carbons are in contact when the lamp is out of action, then a mechanism is required simply to part them as soon as the current is turned on. The operation of producing the arc by parting the carbons is known as "striking" the arc. The mechanism must be automatic, so as to come into action not only when the current is first turned on, but at any subsequent time if from any cause the arc fails. An adjustment, *b*, of the striking mechanism is also usually added to permit of regulation in the length of the stroke or initial distance between the poles.

[C.] *Feeding Mechanism.*—As the carbons burn away, one or both of them must be propelled forward to maintain the arc at its proper size. This action is called "feeding" the arc. This action ought to take place by small and imperceptible amounts, and as the rate of consumption of the carbons is continually varying, even with carbons of the best modern manufacture, the lamp must itself regulate the rate at which the pencils are propelled forward in automatic correspondence with the consumption for the time being. Further, since the presence of soft and more readily volatilised portions in the pencils seems to be unavoidable, provision ought to be made, so that whenever the pencil

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burns down to such a portion, causing a sudden increase in the volume of the flame or arc—technically called a "blower"—the mechanism of the lamp ought at once automatically to draw apart the pencils to a slightly greater distance. A lamp which has a *retractile* motion in either its feeding or its striking mechanism is superior to one that has not, as it can be used with cheaper and less pure brands of carbons. An adjustment, *c*, for regulating the frequency or range or the feeding movements is usual.

[D.] *Replacement Mechanism.*—When the pair of carbon pencils has burned away, the lamp trimmer has to replace the stumps by a new pair of long carbons. In order to admit these, the carbon holders must be pushed apart to their widest extent. Special mechanical devices for allowing this motion to occur have to be provided in some forms of lamp, whilst other forms need no special device.

[E.] *Moderating Mechanism.*—To prevent the carbon from making too sudden motions, it is usual to add a moderating device, such as a dash-pot, or, in the case of those lamps in which there is a train of wheels, a fan or a governor.

So far, the devices enumerated have been such as are common to all classes of lamps. Those which follow are only required in particular types of lamp.

[F.] *Focussing Mechanism.*—In all those cases where it is desired that the luminous points should occupy a fixed position in space, some additional mechanism is necessary to make the arc lamp keep its focus. In lamps designed for the mere lighting of area, this is not important, and in the vast majority of these the upper carbon descends whilst the lower carbon (the negative) is fixed, the luminous point slowly shifting downwards as the carbons consume. All devices for causing the carbons to move forward at such relative rates as to keep an approximately fixed position for the arc will be discussed, together with their methods of adjustment, *f*, under the heading of focussing mechanism.

[G.] *Change-over Mechanism.*—Lamps that must run for many hours continuously must be supplied with two pairs of pencils, because it is neither practicable nor advisable to use pencils of extreme length. In the double lamps it is appropriate to provide such arrangements as shall cause one pair of pencils to come into operation first, and when these are consumed away shall change over the action, either by electrical or by mechanical devices, so that the second pair of pencils shall come into operation.

[H.] *Cut-out Mechanism.*—Lamps intended for series working must be provided with some contrivance to prevent the extinction of the whole series when from any cause there is a failure of the light in any one lamp. The usual device is a sort of automatic relay arranged in connection with each lamp, to come into operation in the event of its failure, the operation of the device being (1) to cut the faulty lamp out of circuit by simply short-circuiting it, or (2) to substitute for it a wire of suitable resistance, or (3) to replace it by an auxiliary lamp. The device for performing either of the two former operations is technically known as a "cut-out."

Supplementary Contrivances.

In addition to the eight distinct species of contrivances above enumerated, there are numerous details which might be further classified; such, for example, as devices for *clamping* the carbon pencils to their respective holders in true allignment; devices for raising and lowering the lamps. For these, however, there is no space. Neither is it possible to enumerate the devices which have been suggested [Staite, Siemens, Brockie, Andrews, Crompton, Swinburne and others] for *compensating*, in lamps whose action depends on the weight of the descending carbon pencil and its holder, for the diminution of pull as the pencil is consumed.

Schedule of Mechanisms.

A schedule embracing the eight heads above enumerated, if supplemented by statements of the gauges and resistances of the wires used in the windings of the coils, affords a systematic and very convenient method of tabulating the facts concerning the construction of any arc lamp. An example of such schedule, filled up with the data of one arc lamp of recent pattern, will be given at the end of this Paper.

Electro-magnets for Arc Lamps.

As the electro-magnet plays so essential a part in the striking, feeding, and cut-out mechanisms of lamps, a short digression upon the particular forms of electro-magnets appropriate to arc lamps is not out of place. The ordinary treatises on electricity have little to tell about the special properties of different forms of electro-magnet; indeed, this all-important organ in modern electrical engineering has received very inadequate attention from writers on electricity. It is a familiar fact that the attraction of a horseshoe-shaped magnet, whether of steel or iron, varies very greatly with the position of the iron armature, being great at small distances, but very rapidly falling away as the intervening space is increased. To devise a form of electromagnet whose attractive power shall be exerted over a fairly long range was at one time one of the practical problems of electricians, and it has been solved in various ways. The attraction which a solenoid, or tubular coil, exerts, when traversed by a current, upon an iron core introduced within its aperture, is not, in any position of the core, nearly as great as that exercised by an electromagnet of horseshoe type, constructed of equal amounts of metal, and energised by an equal current. On the other hand, the feebler pull of the solenoid upon its core is exerted through a very extended range. And by making the core of conical form, or by winding the coils of the solenoid in a conical fashion, it is possible still more completely to equalise the pull over a long range. Solenoids with cores are used in several well-known types of lamps in which a long travel is required. On the other hand, since the operation of striking the arc requires a short motion not exceeding one-twelfth of an inch, or two millimetres, in all those types of lamp in which a special electro-magnet is used simply to strike the arc, a form of electro-magnet is required which will exert a powerful pull over a short range. Further, for working certain clutch mechanisms and the like, it is desirable that a form of electro-magnet should be

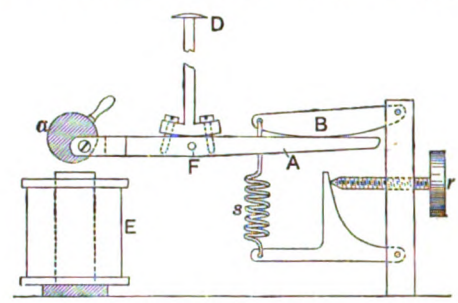

Fig. 1.—Houdin's Equaliser.

found which, whilst having a travel of, say, one inch, should exert throughout the whole of that range a fairly strong pull, increasing, of course, toward the end. Experiments show that the special forms of electro-magnet may be tabulated as follows:—

(*a*) *Short-range Magnets.*—1. Horseshoe form, if constructed with short thick cores, thick yoke and thick armature, giving compact magnetic circuit.

2. "Pot-magnet," straight core with external tubular envelope, connected by iron at bottom. Armature, a stout iron disc or lid.

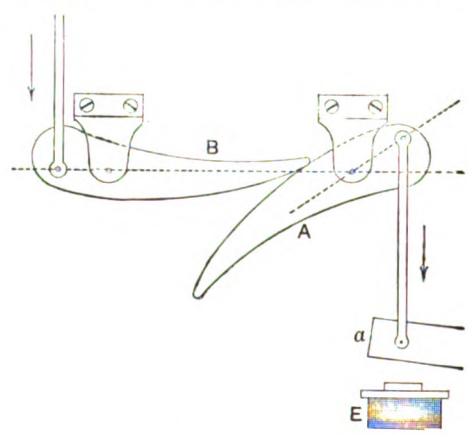

Fig. 2.—Foucault's Equaliser.

(*b*) *Moderate-range Magnets.*—1. Horseshoe form with long thin cores and armature, giving a non-compact circuit.

2. Solenoid having a short fixed core extending part of the way down, and a second movable core to be attracted in as plunger. The name "stopped solenoid" is suggested as appropriate for this form.

3. Two such as last, having a yoke connecting the two fixed cores, and a second yoke connecting movable cores.

4. Stopped solenoid with plunger attached to an outer mantle [Kennedy's lamp].

5. Electromagnet with conical poles protruding through hollow in armature [Thomson-Houston lamps].

6. Electromagnets with oblique approach of armature [Serrin's; De Puydt's; and many other lamps].

(*c*) *Long-range Magnets.*—1. Solenoid, cylindrical, with longer cylindrical core. Attraction greatest when entrant end of core just reaches the further side.

2. Solenoid, cylindrical, with long coned core entering with the point foremost.

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3. Solenoid, conical, with long cylindrical core entering the thicker end of solenoid.

4. Special device for travel of unlimited length. A solenoid constructed in sections, which are switched into circuit progressively ahead of the core as the core travels down.* [Thomas, 578^{82}; Lindemann, 16376^{87}.]

It must be borne in mind that the range of an electromagnet depends on the relative dispositions of the iron parts of the magnetic circuit and of the magnetising copper parts, and in no way upon the question whether the coil consists of a few turns of thick wire, or of many turns of thin wire.

Equalisers.

In sundry forms of lamp special mechanical devices have been introduced for the purpose of equalising, throughout a given range of motion, the otherwise very unequal pull of the electromagnet upon its armature. Set-up springs with adjustable stops have been used for this purpose. A more satisfactory *equaliser (repartiteur)* is the device suggested by the famous conjuror, Robert Houdin, which is depicted in Fig. 1. Here the attraction of the electromagnet, E, for its armature *a*, is transmitted through a system of two curved levers, A and B, which rock on one another at a point of mutual contact which varies the "mechanical advantage" of the system, and partially or wholly, according to the curvature, compensates for the great increase of force as the distance of the armature diminishes.

The form of the equaliser of Foucault, as used in the Foucault-Duboscq lamp, is depicted in Fig. 2. Here the armature, *a*, which is stiffly pivoted eccentrically to allow of adjustment, is attached to a lever, A, whose fulcrum is at F, and the opposing force of a spring, *s* (itself adjustable by the screw *r*) is applied through the curved rocking lever B. The vertical arm attached above F carries the detent D. Equalisers depending on use of a rocking lever are to be found in several lamps. [Serrin's lamp; also Mackenzie, 95^{82}, and Common, 626^{82}.]

Returning from this digression, we have now to go separately over the eight items of the schedule, and point out how the various necessities have been met by the ingenuity of various inventors. As it is impossible to mention all instances of carrying out a principle, reference is made only to a few cases, preferably to the best known lamps

(To be continued.)

LIST OF GERMAN CENTRAL STATIONS.

(PREPARED BY OUR BERLIN CORRESPONDENT.)

Town.	System.	Output in horse-power.	Distribution.
Barmen	Three-wire System (Accumulators)	600	Underground.
Berlin:			
(*a*) Markgrafenstrasse...	Two-wire System	3,900 together	Underground.
(*b*) Mauerstrasse...			
(*c*) Spandauerstrasse*	Three-wire System	2,000	Underground.
(*d*) Dorotheenstrasse*	Three-wire System	2,000	Underground.
Braunscharig*	—	—	—
Bremen*	Three-wire System	600	—
Breslau*	—	500	Underground.
Cologne*	—	—	—
Darmstadt	Three-wire System (Accumulators)	450	Underground.
Dresden*	—	500	—
Eberstadt*	—	100	—
Elberfeld	Three-wire System	325	—
Ems (bathing-place)	200 volts (Multiple series)	100	Overhead.
Frankfort-on-Main*	—	1,000	—
Görlitz*	—	450	—
Halle-on-Saale*	—	550	—
Hamburg	Two-wire System	1,200	Underground.
Königsberg*	—	300	—
Lübeck	Two-wire System	300	Underground.
Magdeburg*	—	500	—
Mühlhausen	Three-wire System	300	Underground.
Olmütz*	—	—	—
Strasburg*	—	400	—

Those marked * are in progress.

From this list it follows that in Germany there exists no central station at all that uses alternating currents; that, generally speaking, the mains and feeders are laid underground; and that for all larger stations the three-wire system is brought into use. From the 16,000 horse-power employed in the German Empire for electric lighting by central stations, exactly one-half are used in Berlin.

* Figures in square brackets relate to patent specification or date.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, March 15th.

Royal Institution.

9 p.m. Evening Discourse. "Beacon Lights and Fog Signals." By Sir James Douglas, F.R.S.

SATURDAY, March 16th.

Royal Institution.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord Rayleigh, M.A., F.R.S.

MONDAY, March 18th.

Society of Arts.

8 p.m. Cantor Lecture IV., 2. "The Decoration and Illustration of Books." By Walter Crane.

TUESDAY, March 19th.

Royal Institution.

3 p.m. Afternoon Lecture. "Before and After Darwin." By George John Romanes, M.A., F.R.S.

Institution of Civil Engineers.

8 p.m. Ordinary Meeting. Discussion on "Indian Railways: the Broad and the Narrow Gauge Systems Contrasted." By F. J. Waring, M.I.C.E. Time permitting, a Paper will be read on "The District Distribution of Steam in the United States." By C. E. Emery, M.I.C.E.

Society of Arts.

8 p.m. Ordinary Meeting. "Objects and Methods of the Society of Arts' Motor Trials." By Prof. A. B. W. Kennedy, F.R.S. The medals awarded at the Society of Arts' Motor Competition will be presented during the evening.

Royal Victoria Hall.

8:30 p.m. Lecture. "The History of a Crime Unravelled by a Piece of Rusting Iron, a Horseshoe and a Match." By Prof. H. E. Armstrong.

WEDNESDAY, March 20th.

Royal Meteorological Society.

7 p.m. Ordinary Meeting. "The Sun: Its Heat and Light." By Dr. W. Marcet, F.R.S. (President).

Civil and Mechanical Engineers' Society.

7 p.m. Ordinary Meeting, at the Westminster Palace Hotel. "The Newmarket Waterworks." By F. Telford.

THURSDAY, March 21st.

Royal Institution.

3 p.m. Afternoon Lecture, "Houses and Their Decoration from Classical to the Mediæval Period." By J. Henry Middleton, M.A.

Institution of Electrical Engineers.

8 p.m. Ordinary Meeting. Paper not decided on.

FRIDAY, March 22nd.

Institution of Civil Engineers.

7:30 p.m. Students' Meeting. "The Cyclical Velocity Fluctuations of Steam and other Engines." By H. B. Ransom, Stud.Inst.C.E.

Royal Institution.

9 p.m. Evening Discourse. "The Science of Animal Locomotion in its Relation to Design in Art." (Illustrated by the zoopraxiscope.) By Eadweard Muybridge.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

EASTERN TELEGRAPH COMPANY.—This company announces the payment on April 15th of a dividend of 3s. per share on the Preference Shares of the company, less income-tax, for the quarter ending March 31st; and an interim dividend of 2s. 6d. per share on the Ordinary Shares of the company, free of income-tax, in respect of profits for the quarter ended December 31st. The register of transfers will be closed from April 8th to 15th, both days inclusive.

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Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
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CONTENTS OF THE CURRENT NUMBER.

Notes 525
On the Localisation of a Partial-Earth Fault in a Submarine Cable by Fall of the Fault's Natural Potential. By Harold W. Ansell and Julian E. Young. Illustrated 530
The Discharge of a Leyden Jar. Illustrated 531
Arc Lamps and their Mechanism. By Prof. Silvanus P. Thompson, D.Sc., M.I.E.E. Illustrated 534
List of German Central Stations 537
Meetings of Scientific Societies. 537
Electrical Business in America 538
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 539
The Gravesend Electric Tramway—Series System. Illustrated 541
The American National Electric Light Association.—Report of Committee on Underground Conduits and Conductors 544
Legal Intelligence—
King, Brown and Co. v. The Anglo-American Brush Electric Light Corporation (Limited) 545
The Central Lighting Stations of France 547
American Notes 547
Notes from Paris 547
Notes from Vienna 548
Notes from Brussels 548
Correspondence—
The Davey-Paxman Engine Trials.—Wilson Hartnell ... 548
On the Designing of Continuous-Current Dynamo Machines.—Wm. Geipel ... 549
Intercalating Apparatus for Portable Incandescent Lamps. Illustrated 549
Companies' Meetings, &c.—
The Anglo-American Brush Electric Light Corporation (Limited) 550
The Telephone Company of Egypt (Limited) 552
The Direct Spanish Telegraph Company (Limited) 553
City Notes, &c 553
Companies' Share List 554

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ELECTRICAL BUSINESS IN AMERICA.

The Chicago Convention of the National Electric Light Association, if it has not taught us anything strikingly novel or particularly useful, affords very satisfactory evidence of the growth of electrical industry in the States, and a reasonable prospect of similar progress being made in England—so far, at least, as the dissimilar conditions of the two countries will permit. We are at length starting on more equal terms, and it may be instructive just now to take note of the report which the American Association is able to make, after five years of combined effort, to promote the interests of what, in local parlance, is called "the electrical fraternity." To what extent the Association has contributed to the extraordinary results, the announcement of which was greeted with such enthusiasm at the Chicago meeting last month, is a matter on which we can express no opinion; but if it had done no more than collect and tabulate the statistics which accompany the report, the American Association would have amply justified its existence. The items, in some instances, may be taken as approximate estimates, although the President quotes them with the confidence and precision of a Chancellor of the Exchequer who is about to rate them for the income-tax. But there is no reason to suspect them of exaggeration; and as the totals have been taken year by year for some time past, the comparative rate of progress may be accepted as perfectly trustworthy.

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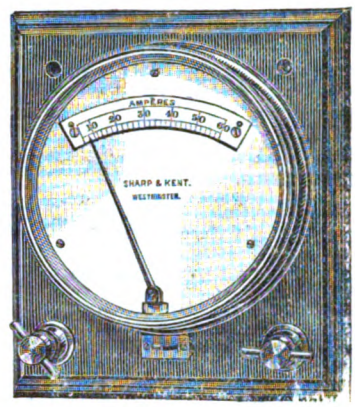

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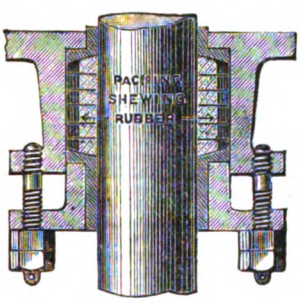

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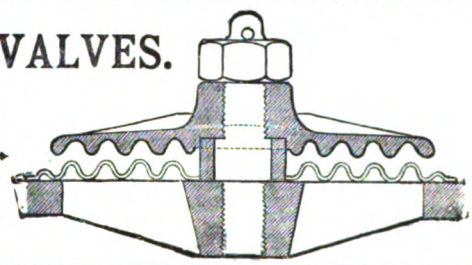

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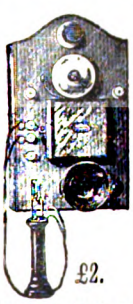

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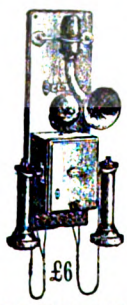

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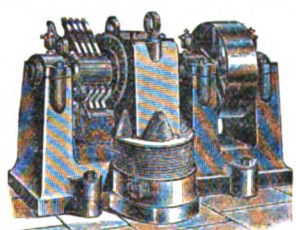

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"THE ELECTRICIAN" INDEX TO ADVERTISERS.

Advertisers in "The Electrician" have their names inserted under the following headings in this Index FREE OF CHARGE.

ACCUMULATORS. PAGE.
Drake and Gorham 4
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) .... —

ALTERNATORS.
Anglo-American Brush Co..... 17

AMMETERS.
Nalder Bros. and Co. ..... —
Sharp and Kent 13

ANCHOR & SHIPS' SMITHS.
Moore (W. and E.) 20

ANTI-FOULING COMPOSITIONS.
Kirkaldy (J.) and Son 20

ASBESTOLINE.
Bell's Asbestos Company 22, 23

AUCTIONEERS AND VALUERS (Mechanical).
King (J. W.) 3
Wheatley Kirk, Price and Goulty 3

BATTERIES.
Fowler, Lancaster and Co..... 3
Gent and Co. 16
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
Latimer Clark, Muirhead & Co. 1

BATTERY JARS.
Joseph Bourne and Sons 2
Cannington, Shaw and Co..... 13
Gent and Co. 16
Price, Sons and Co. 17
J. Stiff and Sons ..... —

BELTING.
Balderston and Co. 17
Moseley and Sons 6
Thompson and Rew 13

CABLE COMPANIES.
Anglo-American Telegraph Co. 25
Direct United States Co..... 25
Eastern Telegraph Co..... 26
Eastern Extension Telegraph Co. 26
Indo-European Co. 24

CABLE SUPPLIES.
Latimer Clark, Muirhead & Co... 1
Elliott Brothers 17
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
R. Johnson and Nephew..... 2
Johnson and Phillips 1
Pirelli and Co. ..... —
M. Theiler and Sons 3

CARBONS.
Anglo-American Brush Co. 17
Barnsley Carbon Co..... 20
General Electric Co. 13
India Rubber & GuttaPercha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
C. A. Müller 4
Thompson and Rew (Carré) 13
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —

CASINGS.
McGaw and Co. 9

CUT-OUTS.
Electric Apparatus Co. 2
General Electric Co. 13
Wood (W.) and Co. 16
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —

CYCLOSTYLE.
Facsimile Apparatus Co..... 24

DISINFECTANTS.
Sanitas Co..... 16

DYNAMO MANUFACTURERS.
Allen and Co. 4
Anglo-American Brush Co. 17
Blakey, Emmott and Co. 2
Clarke, Chapman, Parsons & Co. 8
Latimer Clark, Muirhead & Co.. 1
Crompton and Co. (Limited).... 12
Edison & Swan United Electric Light Co. 5
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
Holmes (J. H.) and Co. 4
M. Immisch..... 18
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2
Laurence, Paris and Scott (Ltd.) 18
Paterson and Cooper 2
Sharp and Kent..... 13
Statter and Co. 2
Thompson and Rew 13
United Electrical Engineering Co. 554
Western Electric Co. 18

EBONITE & VULCANITE.
Harburg India Rubber Co. ..... —
D. Moseley and Sons 6

ELECTRIC BELLS.
General Electric Co. 13
Gent and Co. 16
India Rubber & Gutta Percha Co. 12, 16

ELECTRIC BELLS—*(cont.).* PAGE.
Johnson and Phillips 1
King, Mendham and Co. 9
London Electric Wire Co. 2
Julius Sax 2
Western Electric Co. 18
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —

EDUCATIONAL.
School of Electrical Engineering —

ELECTRIC LIGHT.
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co..... 2
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 8
Crompton and Co. (Limited).... 12
Drake and Gorham..... 4
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
Gent and Co. 16
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 9
Laing, Wharton and Down (Thomson-Houston) 2
Paterson and Cooper 2
Schmidt-Douglas Electric Co. .. 3
Statter and Co. 2
United Electrical Engineering Co. 554
Woodhouse and Rawson (Ltd.).. —

ENGINEERS & CONTRACTORS
Allgemeine Elektricitäts-Gesellschaft, Berlin 10
Allpress and Belshaw ..... —
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co.... 2
Booth, Ellson and Co. 11
Latimer Clark, Muirhead & Co. 1
Chamberlain and Hookham 10
Clarke, Chapman, Parsons & Co. 8
Crompton and Co. (Limited).... 12
Drake and Gorham 4
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) ..... —
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 9
Laing, Wharton and Down 2
Laurence, Paris and Scott (Ltd.) 18
Nalder Bros. and Co. ..... —
Paterson and Cooper 2
Phillips Bros. 2
Julius Sax 2
Schmidt-Douglas Electric Co. .. 3
Sharp and Kent..... 13
J. S. Starnes and Sons 8
M. Theiler and Sons 3
Thompson and Rew 13
United Electrical Engineering Co. 554
Verity (B.) and Sons 7
Woodhouse and Rawson (Ltd.).. —

ENGINE PACKING.
Beldam Packing and Rubber Co. 13
Bell's Asbestos Company 22, 23
J. S. Starnes and Sons..... 8

ENGINES.
Bumsted, F. D. ..... —
Crossley Bros..... 21
Davey, Paxman and Co. 12
Marshall, Sons and Co..... —
Ransomes, Sims and Jefferies .. 9
Richards and Co. ..... —
Robey and Co. 6
Statter and Co. 2

EXCESS ALARMS.
Drake and Gorham 4

EXPANSION SHEETING AND RINGS.
Bell's Asbestos Company 22, 23

FENCING.
R. Johnson and Nephew 2

FIRE RISKS.
Phœnix Fire Office 3

FITTINGS for ELECTRIC LIGHT
Crompton and Co. (Limited).... 12
General Electric Co. 13
Gent and Co. 16
Johnson and Phillips 1
King, Mendham and Co 9
Laing, Wharton and Down..... 2
C. A. Müller 4
United Electrical Engineering Co. 554
Verity (B.) and Sons 7
Western Electric Co. 18
Wood (W.) and Co. 16
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —

FUSES.
Fowler, Lancaster and Co. 3

GALVANOMETERS.
Nalder Bros. and Co. .....

GAS LIGHTERS (ELECTRIC).
General Electric Co. .....PAGE 13
King, Mendham and Co. 9
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —

GLOBES.
Fowler, Lancaster and Co..... 3

INDIA RUBBER.
D. Moseley and Sons 6
Pirelli and Co. ..... —

INFLUENCE MACHINES.
King, Mendham and Co. 9

INSTRUMENTS.
Blakey, Emmott and Co. 2
Latimer Clark, Muirhead & Co. 1
Crompton and Co. (Limited).... 12
Elliott Brothers..... 17
General Electric Co. 13
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. 9
Nalder Bros. and Co. ..... —
Sharp and Kent..... 13
Statter and Co. 2
M. Theiler and Sons 3
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —

INSULATORS.
Joseph Bourne and Son 2
Latimer Clark, Muirhead & Co. 1
W. T. Henley's Teleg. Works Co. 1
IndiaRubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Price, Sons and Co. 17
J. Stiff and Sons ..... —

IRON ROOFS & BUILDINGS.
Francis Morton & Co. 9

IVORY LABELS.
Endolithic Ivory Co. 11

LAMPS.
Anglo-American Brush Co. (Arc and Incandescent)..... 17
Bernstein Electric Co. (Incandescent) 2
Crompton and Co. (Limited).... 12
P. S. Dyer (Edison Incandescent) 2
Edison & Swan United Electric Light Co. (Incandescent) 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
Holmes (J. H.) and Co..... 4
Johnson and Phillips (Arc) . 1
Laing, Wharton & Down (Edison & Swan) 2
C. A. Müller 4
Statter and Co. (Arc) 2
Sunbeam Lamp Co. 8
United Electrical Engineering Co. 554
Western Electric Co. (Arc)..... 18
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —

LIGHTNING CONDUCTORS.
Gent and Co. 16
Johnson and Phillips 1
King, Mendham and Co. 9
Julius Sax 2

LUBRICANT
Bell's Asbestos Company 22, 23

MANUFACTURING ELECTRICIANS.
Latimer Clark, Muirhead & Co.. 1
Drake and Gorham 4
Electric Apparatus Co..... 2
Elliott Brothers..... 17
Elwell-Parker (Limited) ..... —
General Electric Co. 13
Gent and Co. 16
W. T. Henley's Teleg. Works Co. 1
IndiaRubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co..... 9
Nalder Bros. and Co. ..... —
Paterson and Cooper..... 2
Julius Sax 2
M. Theiler and Sons 3
United Electrical Engineering Co. 554
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —

MEDICAL APPARATUS.
General Electric Company..... 13

MEDICAL ELECTRICITY.
Institute of Medical Electricity. —

METERS (ELECTRICITY).
Chamberlain and Hookham 10

MICA.
F. Wiggins and Sons 13

MOTORS (ELECTRIC).
Anglo-American Brush Co. 17
Elwell-Parker (Limited) ..... —
Holmes (J. H.) and Co..... 4
M. Immisch..... 18
Shippey Bros. (Limited) ..... —

NON-CONDUCTING COMPOSITION.
Bell's Asbestos Company 22, 23

OIL FILTER.
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) ..... —

PAINT.
Indestructible Paint Co. 24

PATENT AGENT. PAGE
J. C. Chapman 4

PLATINA SCRAPS.
Jamieson (W. & J.) 10

PRINTING AND ENGRAVING.
Waterlow and Sons (Limited) .. 10

POROUS CELLS.
Joseph Bourne and Sons 9
Price, Sons and Co. 17
Stiff and Sons ..... —

PUBLICATIONS.
Alternate Current Transformers 10
Dynamo Electric Machines 15
"Electrical Plant" ..... —
Electricians' Directory 7
Electric Motor and its Applications 15
Handy Shipping Guide 15
London University Matriculation 10
Patent Laws of the World..... 11
Practical Electricity..... 11
Somali-Land, a Month's Sport in 10
Steam Engine Indicator 15

REGULATORS.
Shippey Bros. (Limited)..... —

RESISTANCE COILS.
King, Mendham and Co. 9
Nalder Bros. and Co. ..... —

SALES BY AUCTION 3

SECOHMMETER.
Nalder Bros. and Co. ..... —

SECONDARY BATTERIES.
Drake and Gorham 4
Electrical Power Storage Co..... 19
Elwell-Parker (Limited) ..... —

SOCKETS.
General Electric Co. 13

SULPHURIC ACID.
Pearce (Wm.) and Sons 16

SUPPLIES FOR CABLE SHIPS
Fritz and Co. 19
F. Lack and Sons 20, 24
Moore (W. and E.) 20
J. S. Starnes and Sons.... 6
Duncan Wallet and Co. 2

SWITCHES.
Crompton and Co. (Limited) 12
Drake and Gorham 4
Edison & Swan United Electric Light Co. 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
General Electric Co. 13
Holmes (J. H.) and Co..... 4
Sharp and Kent..... 13
Thompson and Rew 13
United Electrical Engineering Co. 554
Wood (W.) and Co. 16
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) —

TELEGRAPH ENGINEERS.
Latimer Clark, Muirhead & Co.. 1
Elliott Bros. 17
W. T. Henley's Teleg. Works Co. 1
IndiaRubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1

TELEGRAPH PAPERS.
Waterlow and Sons (Limited) .. 10

TELEPHONES.
W. Blenheim and Co. ..... —
Fowler, Lancaster and Co..... 3
Gent and Co. 16
New Telephone Co..... 13
Stanhope Company ..... —
M. Theiler and Sons 3

TOOLS.
Fenn and Co. ..... —

TRANSFORMERS.
Elwell-Parker (Limited) ..... —
Sharp and Kent..... 13

TURNERS.
Samuel Elliott ..... —

VALVE.
Mosses and Mitchell 553

VENTILATING ENGINEERS.
Blackman Ventilating Company. 3

VOLTMETERS.
Nalder Bros. and Co. ..... —
Sharp and Kent..... 13

VULCANISED FIBRE.
Mosses and Mitchell..... 553

VULCANITE.
Harburg India Rubber Co. .... —
D. Moseley and Sons..... 6
North British Rubber Co. 7

WIRE (Covered or Uncovered).
Latimer Clark, Muirhead & Co.. 1
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
R. Johnson and Nephew..... 2
Johnson and Phillips 1
London Electric Wire Co..... 2
Midland Electric Wire Co. 16
Phillips Bros. 2
Phosphor Bronze Company 552
Pirelli and Co. ..... —
W. Rickard ..... —
Western Electric Co. 18

WIRE-COVERING MACHINES.
Barraclough and Co. 16

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Firm.	*Telegraphic Address.*	*Telephone.*
Allen (W. H.) & Co.	Pump London	—
Anglo-American Brush Electric Light Corporation	Magneto London	4564
Balderston and Co.	Balderston Glasgow	—
Barnsley Carbon Co.	Carbon Barnsley	—
Barraclough and Co.	Barraclough, Manchester.	—
Beldam Packing and Rubber Company	Corrugated London	—
Bell's Asbestos Company	Belfry London	4523
Bernstein Electric Lamp Co.	Glolamp London	—
Blackman Ventilating Co.	Ventilator London	—
	Drier Manchester	—
	Blackman Glasgow	—
Blakey, Emmott and Co.	Blakey Emmott Halifax	—
Blenheim (W.) and Co.	Blenheim Egham	—
Bourne (Joseph) and Son	Danesby London	7516
Bumsted (F. D.)	Bags Hednesford	—
Cannington, Shaw and Co.	Cannington St. Helens	11
	Cannington Liverpool	554
Chamberlain and Hookham (Limited)	Solar Birmingham	—
Chapman (J. C.)	Powerful London	—
Clarke, Chapman, Parsons and Co.	Cyclops Gateshead	—
Crompton and Co. (Limited)	Crompton London	1663
	Crompton Chelmsford	—
Crossley Bros.	Crossley Bros. London	—
	Crossleys Openshaw	—
	Otto Glasgow	—
	Eureka Birmingham	—
	Crossley Bros. Newcastle	—
Davey, Paxman and Co.	Paxman Colchester	—
Direct United States Cable Co.	Direct London	-
	Direct Liverpool	—
Drake and Gorham	Accumulator London	807
Dyer (P. S.)	Dyer Anvers	—
Eastern Telegraph Co. (Station)	Eastern London	1258
Eastern Extension Telegraph Co.	Occidental London	1107
Edison and Swan United Electric Light Co.	Ediswan London	3146
	Ediswan Ponder's End	—
Electric Apparatus Company (Limited)	Campanile London	—
Electrical and Industrial Exhibition	Exhibit Birmingham	—
"Electrical Plant"	Indices London	1533
Electrical Power Storage Co.	Storage London	338
Elliott Brothers	Ohm London	3852
Elliott (S.)	Samuel Elliott Newbury	—
Elwell-Parker Limited	Electric Wolverhampton.	—
Endolithic Ivory Company	Dendron London	—
Felten and Guilleaume	Fredennis London	559
	Carlswerk Mulheim Rhine	-
Fowler, Lancaster and Co.	Energy Birmingham	—
General Electric Co.	Electricity London	1887
Gent and Co.	Genta Electricians Leicester	—
Glover (W. T.) and Co.	Phonoscope London	6691
	Walter Glover Salford	1187
Henley's (W. T.) Telegraphic Works Co.	Henleys Works London	1784
Holmes (J. H.) and Co.	Holmes Newcastle-on-Tyne	278
	Vermilionette London	—
Immisch	Immisch London	7585
India Rubber, Gutta Percha & Telegraph Works Company	Silvergray London	1726
Institute of Medical Electricity	Vigour London	—
Johnson (R.) and Nephew	Johnsons Manchester	370
	Johnsons Ambergate	—
	Resistance London	337
Jamieson (W. and J.)	Dental London	—
Johnson and Phillips	Juno London	1010
King, Mendham and Co.	Kingham Bristol	25
Kirkaldy (J.) and Son	Kirkaldy London	—
Laing, Wharton and Down	Whardown London	3602
Latimer Clark, Muirhead and Co.	Regency London	—
London Electric Wire Co.	Electric London	106
Manchester Electric Works Co.	Induction Manchester	—
Marshall, Sons and Co.	Marshalls Gainsboro'	—
	Engine London	6648
Moore (W. and E.)	Employment London	—
Morton (Francis) and Co.	Dropper London	—
	Ironsides Liverpool	624
Moseley (D.) and Sons	Moseleys London	363
	Moseleys Manchester	—
Mosses and Mitchell	Insulator London	—
Nalder Bros. and Co.	NalderWestminster London	3120
New Telephone Co.	Phonic London	—
North British Rubber Company	Weba Edinburgh	—
	Weba Glasgow	—
	Weba Liverpool	—
	Weba Manchester	—
	Ebwa London	370
Paterson and Cooper	Patella London	1140
Phillips Bros.	Flexible London	5422
Phosphor Bronze Company	Phosphor Bronze London	4557
	Phosphor Birmingham	—
	Phosphor Liverpool	—
Pirelli and Co.	Societa Pirelli Milano	—
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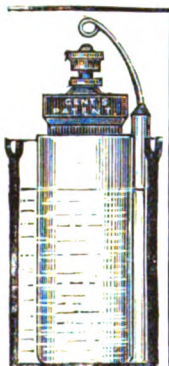

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Turning to these statistics, and confining ourselves to what they reveal of the progress made during 1888-9, we find that, of 5,747 electrical installations believed to be in operation at the beginning of last month only 4,000 were in existence on February 1st, 1888. The actual designation used in the report is "central stations and isolated plants," but whatever these terms may represent, the increase is very remarkable. The President, "figuring in percentages," reckons this an increase for the year of 45·8 per cent., which calculation we do not quite comprehend. Without figuring in percentages, however, we can easily see that, in what follows, the progress indicated is equally gratifying. Arc lamps, which in February, 1888, were estimated as numbering 175,000 in actual use, attained the handsome total of 219,924 at the same date in 1889. A still larger increase, as might be expected, has taken place in the use of incandescent lamps, the number last recorded being 2,504,490, whereas twelve months previously there were only 1,750,000—an increase for the year of more than 750,000. The progress made with electric railroads, including, of course, roads which we should call tramways, is, considering the comparative infancy of this industry, even more striking. During the six months ended February, 1889, for which alone any trustworthy information is obtainable, the number of such railroads has increased from 34 to 53, all of which are now in operation carrying traffic; whilst 44 additional lines are known to be in process of construction. A perhaps more trustworthy proof of their practical application is found in the fact that new cars put upon these lines have in the short period of six months increased from 223 to 378. The mileage in the same period has been augmented by 157½ miles, making the present total single track electric lines in operation 294½ miles; and there are at this moment almost as many miles of line—the exact figures being 273¾ miles—under contract and in course of construction.

Some remarkable figures are given relating to the amount of capital invested in the Electric Light Companies of the United States. We are not told whether this capital is wholly devoted, or to what extent, to electric lighting business; probably like the Association itself, the title in many instances covers the whole field of electrical industry. But be this as it may, from the announcement that fresh capital raised by these companies during the past twelve months amounted to $69,397,734 (equal to about 13 millions sterling) we can form some idea of the strides which electrical business is making on the other side of the Atlantic. The National Electric Light Association of America may well take a sanguine view of its future prospects. Its President is reported to have said that although the Association numbered among its members "every gentleman actively interested in the electrical distribution of light and power, it was an undisputed fact that it ought to include three times that number," and he added, by way of explanation apparently, that "the enormous growth of the industry, and the consequent influx of hundreds of men into its ranks," would lead to a greater increase in the roll of members than there had ever been before. As we may not suspect an American citizen of inventing a class distinction between gentlemen members and men non-members, we can only surmise that he means there is a lot of money to be made by following the fortunes of the Association, and that those men who at present stand aloof have a chance of becoming gentlemen if they step inside. Of course this is mere conjecture; but having regard to the enormous amount of capital being put into the business with which it is identified, we would not be surprised if a very large number of the outside public gradually found it to their interest to join the ranks of the Association.

Some rather lively discussions took place at the meetings which occupied the Convention during its three or four days' sitting. We have only space to refer briefly to what occurred in reference to the "mooted question," or the "live question," as it is variously termed, of underground wires. The Chairman's patience was taxed considerably to keep the "gentlemen" in order whose opposing views or conflicting interests found emphatic expression on that particular topic. Those who had specifics for all the ills which underground wires are heir to were by no means backward in prescribing, whilst those who had wires at present above ground showed a sturdy reluctance to put them on the sick list for purposes of experiment. Our New York contemporary, the *Electrical World*, is glad that the Convention did not declare "the undergrounding of high-tension wires to be entirely feasible," adding the suggestion, equally diplomatic and oracular in its way, that this is a matter that will be "settled as we go." The "underground men," as our contemporary calls them, are, in its opinion, perfectly sincere in their advocacy; and their opponents—daylight men we suppose they must be called—are not less sincere in theirs. Further ventilation is needed; and meanwhile we are to be content with the assurance that "the final solution is neither of to-day nor of to-morrow." On the question of municipalities acquiring electrical undertakings greater unanimity prevailed, there being hardly any criticism on Messrs. FOOTE and WHIPPLE'S contention that neither government nor municipality can engage in commercial business with profit or advantage to the public. There is perhaps something to be said on the other side; but as we have no wish to import into America any of the impending troubles which threaten to embarrass electric lighting industry in this country, we shall discreetly abstain from furnishing arguments to the common enemy.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION III.—MAGNETIC FIELDS OF COILS AND SOLENOIDS.

(*Continued from page 480.*)

147. *General Character of Field Due to a Solenoid.*—In considering the way to determine the strength of magnetic field

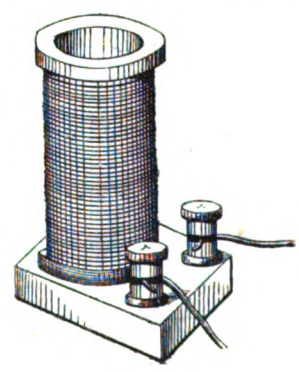

FIG. 139.

at any point on the axis of a ring conductor carrying a current, we gave ourselves a more extended and more general view of the subject than when determining the field at the centre of the coil only. In other words, the latter case is involved in the former, and the student will find it best to master the more general case, because he will then be able to apply it to any special case required. The determination of the field at any point along the axis of a solenoid is the most general case of all, and it will therefore be the last case we shall examine in this section. At the same time, this most general case is the most difficult one to be followed and understood, and the writer

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hopes, at any rate, to lead up to the final result by a series of easy steps. It will be well here, as previously done, to get a general idea of the character of field exhibited by a solenoid next; to consider the *direction* of the field, and finally its *intensity* in C. G.-S. measure at any point along the axis. This being done, the student will find that he is in a position to intelligently understand the various forms in which galvanometers are constructed. A single low-resistance cell connected to the terminals of a solenoid wound with a few layers of No. 18 or No. 16 double cotton-covered wire will be sufficient to exhibit the general contour of the magnetic field set up in and around the coil. It is better to mount the solenoid on a bit of wood, as in Fig. 139, and carry the two ends of the coil through the wood and along two

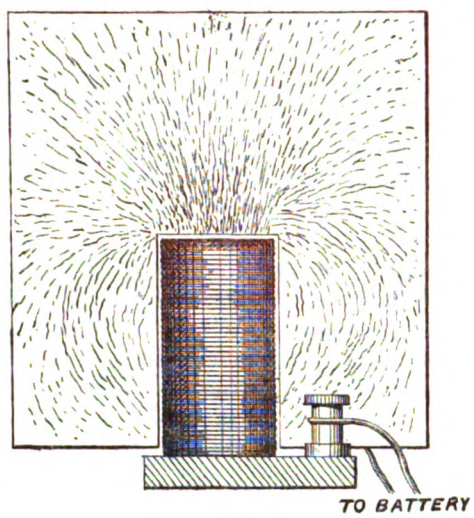

Fig. 140.

slots underneath leading to their terminals. Done in this way you can have two sensible terminals to connect your wires to, instead of the flimsy little terminals sometimes screwed on to the cheek of the bobbin, which frequently cause splitting of the same, or, at all events, make bad contact with the coil.

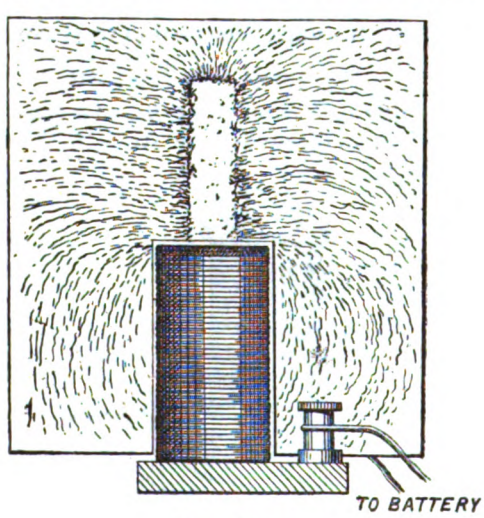

Fig. 141.

After winding, the bobbin may be fixed rigidly to the wooden base by countersinking a hole in the latter deep enough to receive the lower cheek of the bobbin flush with the level of the base. A couple of semi-circular pieces of brass plate covering the cheek and the contiguous part of the base may then be screwed down to the latter, holding the coil firmly in position. Or a piece of brass sheeting may be cut so as to fit over the top cheek and come down in a half-inch strip each side, and be firmly screwed on to the base below. In any case, screws should not be fastened into the cheeks themselves. The solenoid could be fixed horizontally in much the same way on to a base board, but its position will depend on what kind of experiments are to be made with it. When finished, it can be used for a variety of experiments, such as the mechanical pull it exerts upon an iron core to draw it into the coil. This can be varied by trying different kinds of core, such as, for instance, a core built of a bundle of small iron wires and cores of different shapes with pointed and blunt ends, &c., measuring the pull on a spring balance, when, say, a given core has different portions of its length introduced into the coil. The outside layer of wire on the coil should be well brushed over with thick shellac varnish (shellac dissolved in alcohol). This soaks in and hardens the cotton covering, protecting it from abrasion in handling. Curves made from the plotting of the observations above indicated are very useful in showing the action of cores working in solenoids in arc lamps, especially the difference between the pull on a core which moves *with* the carbon rod, as, for instance, in the Pilsen lamp, and that on a core which generally maintains a certain position relative to the coil, as in the Brush or Siemens. The foregoing remarks are merely to indicate what useful experiments and tests may be carried out with a solenoid; to go into detail in this direction would more befit a separate treatise on electric lighting, and is outside our present limits. Taking, then, such a solenoid and laying it down horizontally, we can examine the character of field by iron filings sprinkled on a card supported close to it, as shown (Fig. 140). When the current is on and

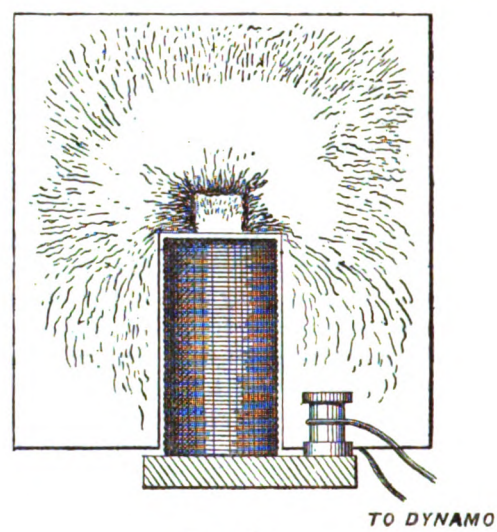

Fig. 142.

the filings are sieved down gently they will be found to arrange themselves as indicated in the figure, and it is easy to see that the solenoid exhibits the same kind of field as a permanent magnet whose length is in the same direction as the length of the solenoid. Further, we can better understand what goes on in the interior of a bar magnet by noticing the kind of field that we get *inside* the solenoid. This is best examined with a small compass needle, which we shall do shortly. Taking an iron core, fitting into the solenoid, and of about the same length, it is interesting to observe that when the core is very nearly out of the coil, as in Fig. 141, the shape of the field is considerably altered. The reason that no iron filings adhere to the card just over the iron core is because the core itself absorbs those lines of force which otherwise would pass through the air and attract the filings. So easy a path does the iron core offer in comparison to the air that the lines pass straight from the interior of the coil into the iron core for some distance before passing outward in the usual curves to complete the magnetic circuit, and this causes the alteration in the shape of the field. The projecting end of the core is strongly magnetised, and its magnetism will be reversed if the direction of current in the coil is reversed. Also, if the core is right inside the solenoid, we have virtually an electro-magnet, and with a direct current we get the same field as we have before shown for electro-magnets. With an alternating current through the coil, however, such a vibration is set up that immediately the filings touch the card the greater part of them dart at once to the core. This effect is shown in Fig. 142.

(To be continued.)

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THE GRAVESEND ELECTRIC TRAMWAY—SERIES SYSTEM.

The tramway line of the Series Electrical Traction Syndicate (Limited), which has just been completed and opened at North-

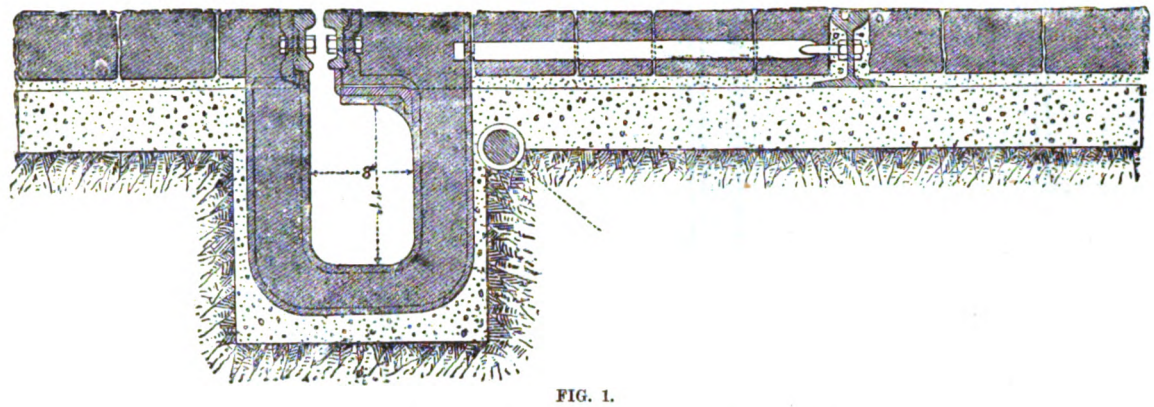
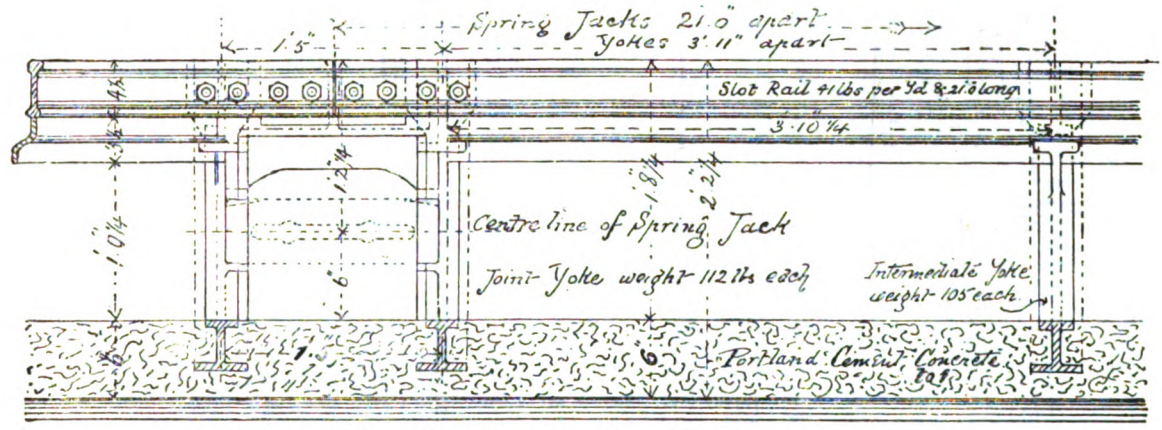


FIG. 1.



LONGITUDINAL SECTION THROUGH SLOT

FIG. 2.

fleet, has been built chiefly in order to demonstrate the practicability of series working. The importance of the successful working of cars in this manner will be appreciated by all electrical engineers, as removing many difficulties in the way of the application of electricity to large tramway systems by means of parallel distribution. In fact, in electric traction, high tension obviously plays the same *rôle* as in electric lighting, with the difference that, from a purely electrical point of view, constant-current working is much more easily carried out in the former case than in the latter. The Series Traction Syndicate, moreover, claims that it has now successfully overcome all the mechanical difficulties which have arisen in the earlier experiments upon the same system in America.

In order to make this system suitable for adoption in the ordinary roads and streets, the first point to be considered in designing the mechanical details was the construction of such a conduit as would cause the least possible interference with the surface of the roadway, and would be of sufficient structural strength to provide for the heavy traffic of our large towns. In order to avoid a greater interference with the surface of the road than is common to ordinary horse tramways, it was decided in the first instance that the conduit should be laid directly under one of the track-rails, and not, as in the case of cable tramways, centrally to the track. The further consideration of interfering as little as possible with the water and gas mains existing below the surface of the roads required that this conduit should be kept to the smallest possible dimensions consistent with practical working.

The tube, as constructed at Gravesend, is 8in. in width, the bottom being 13in. below the surface of the road. This slot,

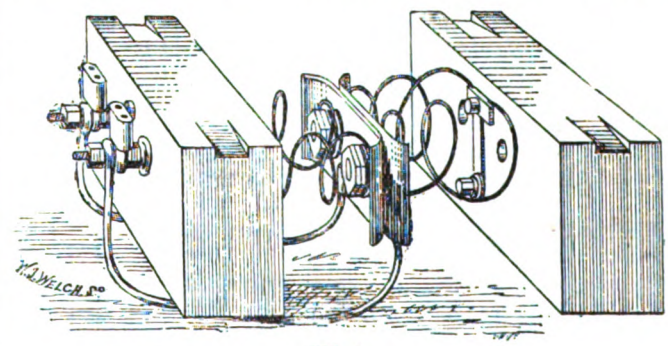


FIG. 3.

through which contact is made between the underground conductor and the car-motor, is formed by leaving a space of $\frac{7}{8}$in.

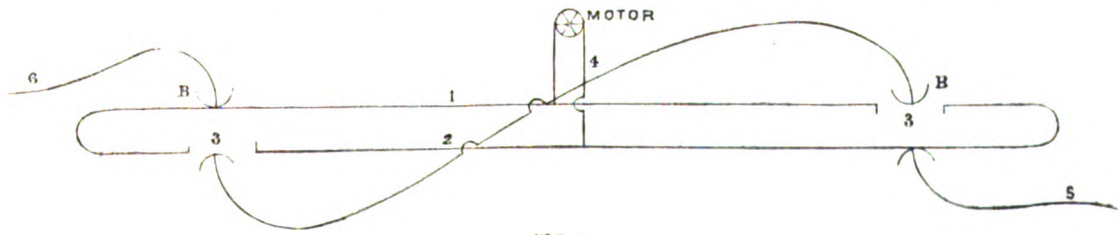


FIG. 4.

between two bull-headed rails, somewhat similar to the ordinary Vignole's railway rail, these being 4$\frac{1}{2}$in. in depth, with upper flanges 1$\frac{3}{4}$in. wide. The outer of these rails serves as the tread

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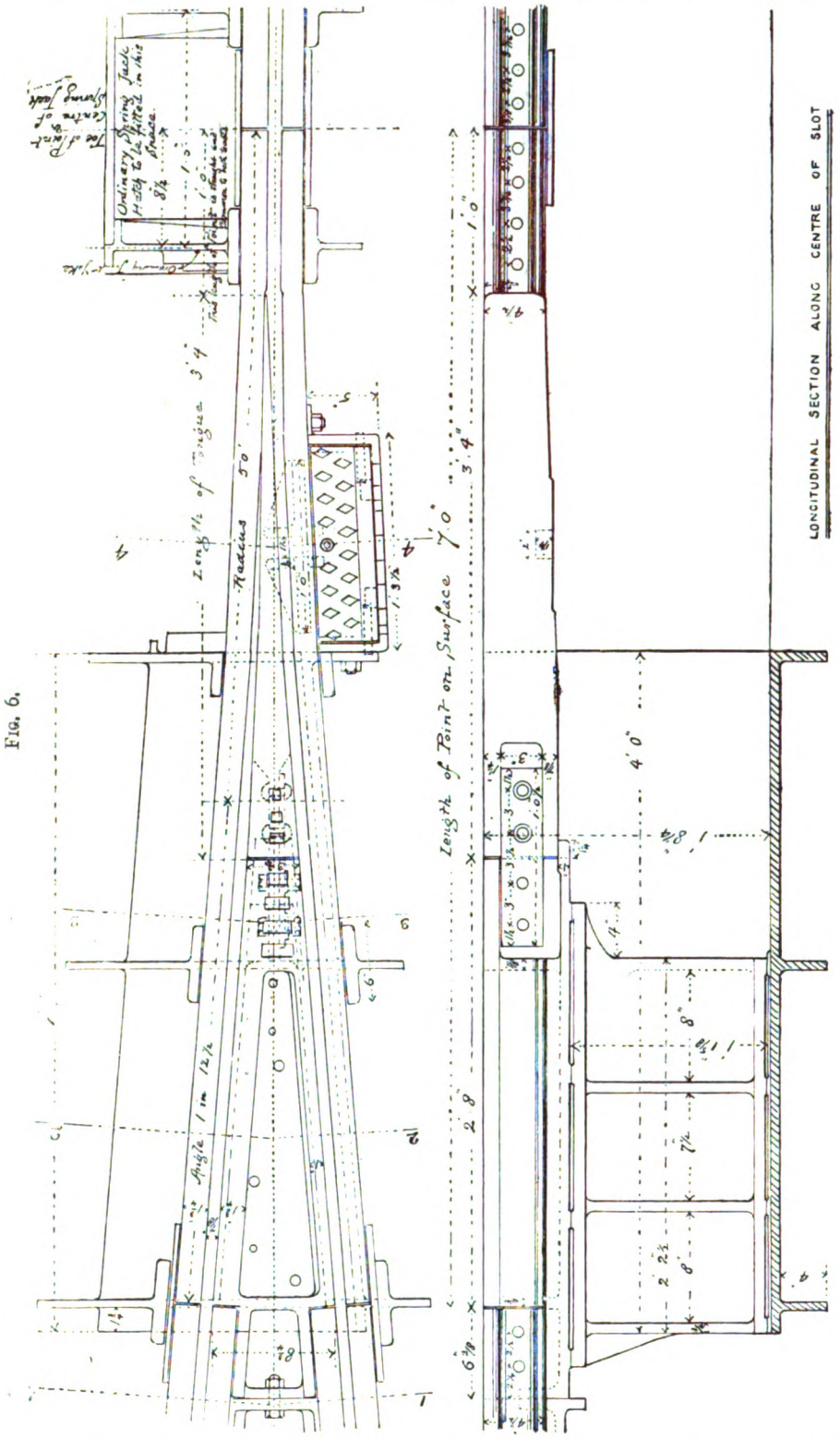
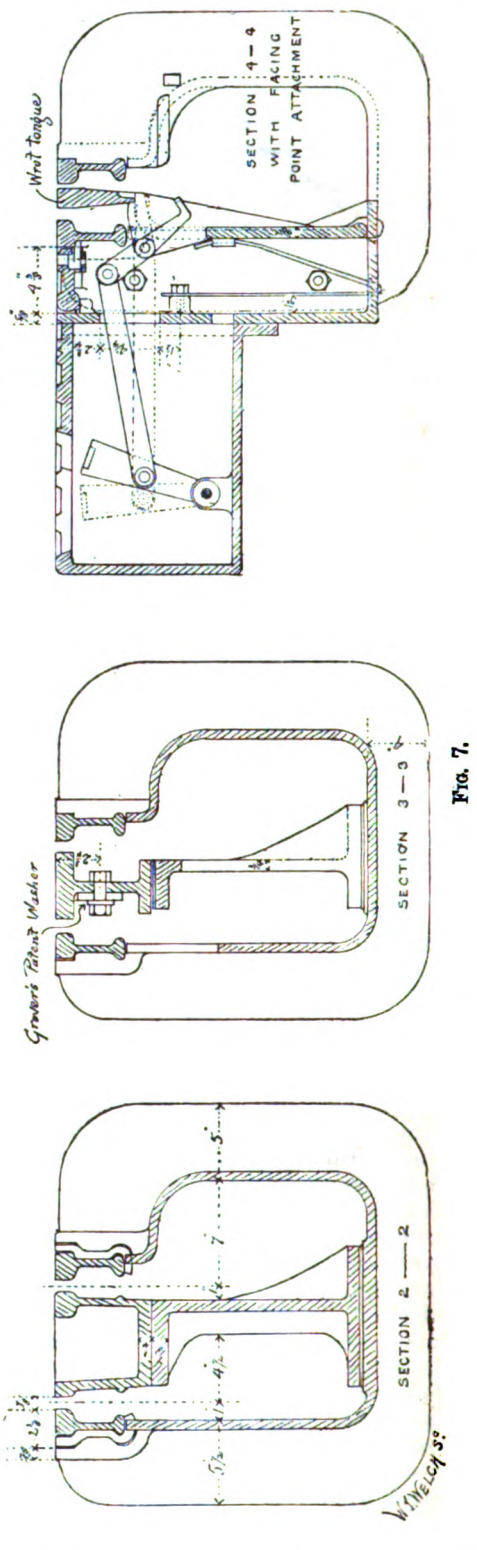
for the tramway wheel, the inner corresponding to the guard-lip of an ordinary tramway rail. These rails are secured through their webs to cast-iron chairs or yokes, at intervals of about 4ft., the yokes being of such section as to leave a clear space below the bottom flange of the rail of 13in. by 8in. The walls of the conduit between the yokes are formed of Portland cement concrete 6in. thick. The rails are laid in lengths of 21ft.; the yokes on either side of the joints being placed 1ft. 5in. apart, centre to centre, and a chamber is formed where these joints occur, covered on the inner side of the rail by a small hatch, 1ft. 4½in. by 8½in., recessed on the surface and filled with wood-paving blocks. These chambers serve for the purpose of access to the "spring-jacks," or contact points, to which reference will be made further on, and also admit of the removal of any dirt which may possibly accumulate in the tube; and, further, give facility for tightening up the fishplates at the rail joints. The corresponding tramway rail is of the ordinary girder type, the gauge being maintained by means of tie-bars attached to the girder rails on the cast-iron yokes, and require no further description. Figs. 1 and 2 show the ordinary construction of the roadway in detail.





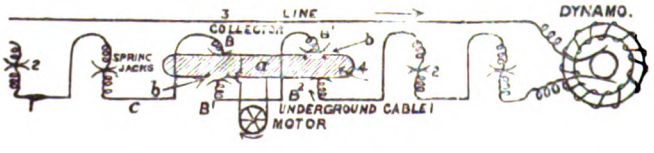


Fig. 5.

Along each side of the track, buried in the concrete, is an earthenware tube 3in. in diameter (*see* Fig. 1), the ends of

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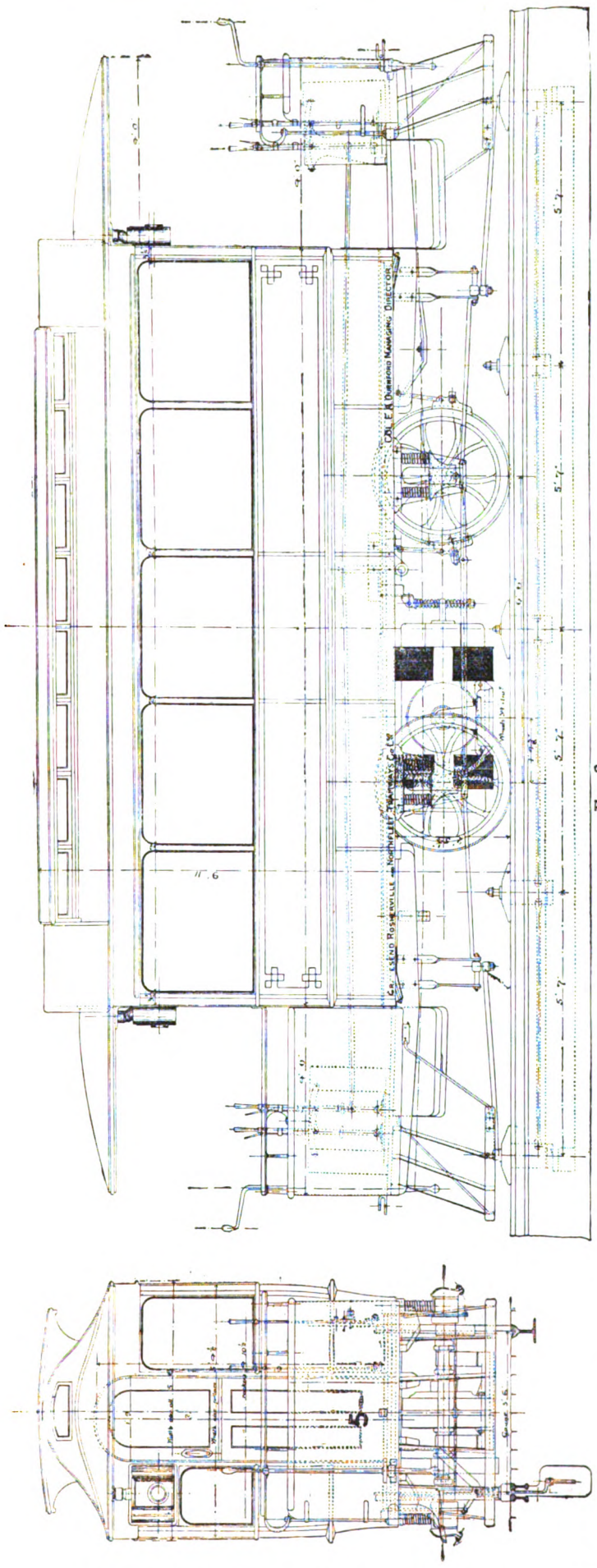

FIG. 8.

which protrude into the cavity formed under the conduit hatches where they are open for access. Into these tubes are drawn lengths of about 21ft. of Henley's ozokerised rubber cable of an insulation resistance of 7,500 megohms per mile, and also the unbroken return cable from the extreme end of the line. These short lengths of highly-insulated cable are the only conductors between the "spring-jacks"—the conduit between these points being only for the passage of the arrow, and, therefore, otherwise empty. In each conduit-chamber is placed a "spring-jack," consisting of a pair of glazed earthenware blocks, 14ft. by 3ft. 4in., supported on brackets, cast on to the joint yokes, the blocks facing each other on opposite sides of the tube. To each block is attached, by means of a double spiral spring, a gun metal casting, curved at the ends, but flat in the centre. The springs are of sufficient strength to press the two castings together with a force of 6lb. The "spring-jack" is shown in Fig. 3. Under the car, and for its full length, is the collector, or the "arrow," which consists of two thicknesses of india-rubber belting, each having a broad brass strip rivetted to it for nearly its entire length. The nose of the arrow at each end is shod with wrought iron brought to a knife edge, so as to easily force its way in between the two faces of the "spring-jack." The maximum thickness of the arrow is 1in., which is consequently the extent to which the gun-metal cheeks are separated. The conductor on each side of the arrow is lapped round one end, and an insulated space is left, slightly greater than the surface of contact of the "spring-jack," near the extreme ends on opposite sides, as will be seen by the diagram, Fig. 4, where 1 and 2 represent the conductors by the insulated gaps and B the "spring-jack" cheeks. With this arrangement it will be seen that in the passage of the arrow from one "spring-jack" to the other, one-half of the "spring-jack" that is being entered, and one-half of the "spring-jack" that is being left, together with the length of cable between them (2), is completely cut out of circuit, the current being, meanwhile, supplied to the motor from the remaining halves of the "spring-jack." It will be readily seen from this that at no moment is the current cut off from the motor, nor is the motor at any moment short-circuited; in fact, the ammeter carried on each car shows the constant value of the current without any variation. Diagram Fig. 5 shows the arrangement of the entire circuit with an arrow passing through the "spring-jacks." The "spring-jacks" themselves are arranged to be taken out or replaced in the conduit in the course of a few minutes. Short-circuiting pieces are provided to enable the continuity of the circuit to be maintained should a "spring-jack" require to be replaced without interrupting the service during the operation, the car easily running by its own momentum through the distance of 21ft., in which it would receive no current. The "spring-jacks" themselves are very simple pieces of apparatus of small cost, and the contact they make by their surfaces being pressed together is excellent, the resistance of the line being but very little higher than that calculated from the direct resistance of the insulated cables themselves. At the turnouts the junction of the conduits underneath the road necessitates the construction of somewhat special points and crossings. The points are provided with movable tongues set so as to automatically direct the traffic to the left hand side of the road, and in order to avoid risk attendant on having a long unsupported tongue forming the roof of the conduits at their junction, a special tumbler has been designed, so formed that it provides a support for the point of the tongue under ordinary conditions, but during the passage of a car it is deflected out of position so as to allow a full clearance for the current collector or "arrow." Where it is necessary, as, for instance, at the terminal fork at the Northfleet Station end of the line, to provide a means by which the cars can be caused to take either track, a claw is pivoted on to the tumbler which can, by means of a lever, be made to engage with the under surface of the tongue, and thus draw it into the required position. Details of the points are shown in Fig. 6, and details of the accompanying crossings where the slot rails cross the girder rail in Fig. 7.

The cars used at Gravesend, which are supplied by the Falcon Engine and Car Works, Loughborough, are shown in Fig. 8. The motors are mounted on the shafts of the car, and are run

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at 400 revolutions per minute, delivering at this speed, when the field-magnets are fully excited, 15 horse-power on the brake. The motors, which were made by Messrs. Elwell-Parker, are supported in front by two bearings on the driving shaft of the car, the rear being suspended by a spiral spring from the car body. A double helical pinion on the motor shaft drives directly a spur wheel on the car shaft, in the ratio of 1ft. 4½in. This gearing works with great smoothness.

The regulation of the motor is attained by massively-constructed switches mounted on each platform. One switch reverses the connections of the field so as to reverse the direction of the car; the other regulates the resistance of a shunt to the fields, so as to weaken or strengthen it, in proportion to the power required.

One of the cars is lighted electrically by means of low resistance lamps of the Bernstein make. Three accumulator cells, each of 31 plates of the tramway type of the Electrical Power Storage Company, are inserted in the main circuit, and five lamps of 10 amperes each and 65 volts are run in parallel off the accumulators. The accumulators themselves, however, are not discharged; they only serve as potential reducers, the whole of the main current going through the lamps. Should one of the lamps break the remainder are a little more brightly incandesced, and the current due to the broken lamp passes through the accumulator. A two-way switch enables the accumulator to be taken in or out of the main circuit, and the cells are large enough to run all the lamps without assistance from the main current should it be requisite. The arrow is shown in Fig. 8 in position under one side of the car. It is supported at distances of 5ft. 7in. on cast-iron bearing blocks, sliding along the surface of the rail. These blocks are connected with iron tie bars, which take all strain off the india-rubber belt, the whole gear being propelled by the car. It being requisite that current of perfectly constant value should be generated to work the system, the Syndicate selected one of Messrs. Statter and Co.'s constant current machines. This machine fulfils the rather arduous conditions which are imposed upon it perfectly, the E.M.F. being continually varied from a few volts to upwards of 400, the current always remaining constant at 50 amperes. The sparking at the brushes is of the most trifling description, notwithstanding that they are continuously receiving automatic adjustment, sometimes over an arc of 30 degrees. This result is ascribed to the peculiar shaping of the pole pieces.

The generator is driven by a Robey compound underneath type engine of 10 h.p. nom., with locomotive boiler over it.

It will be seen that, in addition to the economy of running obtained by the series system, the manner in which the details are carried out possesses many advantageous features. The highly-insulated cables used over the greater portion of the line, and the comparatively small surface of conductor exposed at the "spring-jacks," may be expected to result in a fairly high insulation throughout. The divided conductor being in very short lengths, a section can be renewed in a very short time without interfering with the traffic of the line; and the conduit being perfectly empty, excepting at the "spring-jack" chambers, is easily cleaned, and can scarcely require taking up at any time. An incipient fault in the line is easily detected and localised by the car-drivers themselves through the ammeters.

The form of the conduit is such that the "spring-jacks" are not directly beneath, the slot being thus protected from road *debris*, in addition to being placed out of danger of interference from the surface, so that even should an "earth" exist it is impossible that a shock should be received through them.

The "spring-jacks," switchgear, lighting, and sundry apparatus have been supplied by the United Electrical Engineering Company (Limited), 3, Prince's-mansions, Westminster.

The whole of the road work and mechanical details were designed by Mr. Joseph Kincard, M.Inst.C.E., the company's consulting engineer, and the construction was executed for him, under the personal supervision of Mr. J. E. Waller, A.M.Inst.C.E., by Messrs. Dick, Kerr and Co.

All the electrical work has been carried out under the supervision of the company's electrical engineer, Mr. E. Manville.

THE AMERICAN NATIONAL ELECTRIC LIGHT ASSOCIATION.

Report of Committee on Underground Conduits and Conductors.

At the meeting of this Association, held at Chicago on Feb. 19, 20, and 21, Mr. E. T. Lynch, jun., read the following report:—

"At the eighth meeting of the National Electric Light Association, held in New York on August 29, 30, and 31, 1888, the following resolution was adopted:—

RESOLVED: "That a committee of five be appointed to examine and report upon the system of underground conduits now in operation, and the number of wires actually in use in these conduits, and to report at the next meeting of this Association."

The president appointed Messrs. Lynch, Barney, Kerr, Davis, and Crocker as members of that committee. And as chairman of that committee, I beg leave to submit the following report:—

As the resolution called for a compilation of all data connected with the actual placing of electrical wires underground, your committee deemed it advisable to send out a circular, calling upon all the local electric light companies for the results of any practical tests that they had made. To carry out this idea, they caused to be printed the following circular:—

"GENTLEMEN: A committee was appointed at the semi-annual Convention of the National Electric Light Association to investigate and collect all data relating to underground wires and conductors, both in this country and Europe. So many erroneous statements have been made from time to time regarding experiments or tests with underground wiring, that the committee feels that it is necessary to obtain all of the most important details and facts regarding this subject.

"Will you, therefore, kindly answer, as far as may be in your power, the following questions, and return the same to the head-quarters of the Association as soon as possible? Your answers to these questions will be looked upon as confidential, and will not be referred to by name or locality in the report of the committee:—

"1. Have you ever placed underground any electric light conductors, carrying currents at a potential of 1,000 volts or over? 2. If so, state the number of experiments, giving the date of each. 3. What was the length of each individual conductor laid underground? 4. What was the voltage on each conductor? 5. What was the current, in amperes, carried by each conductor? 6. What make and style of dynamo supplied the current on each of these conductors? 7. Were these conductors single or grouped in cables? 8. How many conductors to the cable? 9. What was the size of the conductors used? (In answering this question give the number and gauge.) 10. What was the thickness of the insulation? 11. Who was the maker of the cable? 12. Were the cables laid in any form of conduit? 13. If so, what kind of conduit was used? 14. Describe the manner in which the cables were laid in the conduit—whether drawn in, built in, or otherwise. 15. If the cables were laid directly in the ground, describe the method of laying them. 16. Was there more than one duct in the conduit? 17. If there were other ducts what was in them? 18. Did you have exclusive control of the conduit? 19. What was the total duration of your experiments? 20. Did the cables work satisfactorily during the entire time of your experiments? 21. If not, how long did they work satisfactorily? 22. If the cables failed to work satisfactorily, to which of the following causes do you attribute the difficulty? Please answer as fully as possible:—(*a*) Defective insulation; (*b*) defects in joints; (*c*) defects in making connections from cables to lamps."

These were sent to all of the local electric light companies, and in response to them we have received 130 answers. In presenting and compiling the answers to the various questions that were sent out, we have deemed it advisable to divide them into two classes, as follows:—Those who have had actual experience in placing and running underground electric wires and those who have not had actual experience, but whose opinions we have asked. Of the former class there are but seven. We will here give the details of the placing of the wires underground, the duration of tests, style of conduit used, and the general results, that were received in each of these seven answers.

As it was stated in the circular sent out that all the communications would be regarded as strictly confidential, we have deemed it advisable that the names of the companies or individuals should not be mentioned in this report.

First. The writer has used the underground conductors for three years. Has used wire of three of the most prominent manufacturers. Has discarded two and is now using the third. The cables were carried in a cement pipe and manholes were placed at every 250 feet. Cables had been drawn into the conduits, and as a method of facilitating their drawing in, pulverised soapstone had been used for the purpose of avoiding abrasion.

Only one wire placed in each pipe. He states that the wires have not worked satisfactorily, and that he has been compelled to shut down many times, that they are now running fairly well, but he is obliged to keep them under constant supervision and repair. He accounts for most of the trouble that he has experienced by defective insulation, defective mechanical construction, and by deterioration in the insulation in the wires, having had no serious trouble with the style of conduits that he has used. In answer to the question regarding the practicability of placing his conductors underground, he states:—"We are operating some eight miles of underground wire; we wish there were less, and certainly are not anxious for more." In answer to the question regarding the difficulties and objections to underground wiring, and whether he considered them commercial, electrical, or mechanical, he states:—Electrical. There is no cable that will last with a current from a fifty-light dynamo. Commercial—Owing

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to the large cost of construction and expense of maintenance, and great possibility of breaks, there is consequently poor service and dissatisfaction. He has exclusive control of his conduit.

Second: The writer has made many experiments, in which he has used lengths of cable varying from 200 feet to two miles in length, manufactured by most of the prominent wiring companies. Cables have been laid in and drawn in his own conduits, conduits constructed both of wood and iron. The tests have usually been of short duration, and have been suspended in each case after a failure of the cable to work satisfactorily. The cause of the failure has been mainly defective insulation. Defective mechanical construction, defects in laying, defective conduits, injury to cables in laying or defective joints, have caused very little trouble, the main cause of trouble being in defective insulation and deterioration owing to the presence of gas, water and steam.

His opinion, based upon the results brought out by the many tests that he has made, is that he does not consider it practical at the present time to place conductors underground, the absence of insulation that would stand being the principal reason. If ever that question is settled the cost would, in his estimation, make it commercially impracticable. In only one instance he had the exclusive control of the conduit.

Third: The company represented by the writer had four circuits underground for about one year. One style of cable by a prominent manufacturer was alone used. The wire was drawn into a composition conduit, which had manholes at the corners.

Quite an amount of trouble was caused in the start off, by difficulty caused by abrasion to cable in drawing the wire into the conduit. The experiments were continued for one year. They caused a great deal of trouble within the lighting contracts, and at the end of that time were abandoned. He considers the chief troubles to be defective conduits, water in the conduits, and deterioration of the cable, also trouble in defective insulation, defects in the joints, and trouble in making connections through iron pipes from the conduit to the surface.

He does not consider it practicable to place his wires underground, and states: "I don't know of any system that has yet proved satisfactory;" and further states: "I know of no system to-day which, even at any expense, has proved satisfactory, except a system of subways built large enough for men to walk through their entire length."

In answer to the difficulties of placing wires underground, he states that he considers the difficulties to be commercial, electrical, and mechanical perfection, and still not be so expensive (in the end) as to make the commercial objection insurmountable. He did not have exclusive control of the conduit.

The ordinance passed by the Common Council in his city in 1886 stated 'that their committee had examined the subject, and found the putting of all electrical wires underground feasible, and ordered all wires within a few months, and those outside of this district, underground within one year." He has been brought before the court a number of times on complaint of the city attorney, but nothing yet has been done in the matter.

Fourth: The writer has made two experiments during the last summer, one of which was a failure and the other a partial success, though the duration of the second test and the position it occupied in the circuit was such as to give little importance to the result. The wires were pulled into a wooden conduit, there being two ducts in each conduit. Cables did not work satisfactorily. He states that the failure is due entirely to defective insulation. In answer to the question if he considers it practicable to place his conductors underground, he replies, "We do not with any system known at present." In answer to the last question, concerning the difficulties and objections to placing wires underground, he states: "The difficulty is particularly commercial, though I have seen no system which I think will properly insulate the conductors."

Fifth: The writer has placed two circuits underground about the first of the present year. The cables used are those manufactured by six of the most prominent companies. They have been drawn into an asphalte conduit, 12 ducts in each conduit. The duration of his experiment has only been about a month and a-half, and he states that it is too early to tell what will be considered the result of the experiment. In answer to the question if it would be considered practicable to place the wires underground, he states, "Have seen nothing yet that will answer." In answer to the question as to his opinion regarding difficulties and objections to going underground, he replies, "Chiefly commercial, partly electrical, and partly mechanical." He has exclusive control over his own style of conduit.

Sixth: The writer has had wires in the conduits for about five years. The mains were carried through the streets in a composite system of conduits, the connections are made from the system to the cellars through iron pipes, and the wires are conveyed then through cellars, connection being made from the cellars to the houses. The cellars run completely around the block, and permit of free access to them for the purpose of repairing or making connections to wires.

He has used three different kinds of wires in the conduits, the cables now in use having been in position for about thirteen months; although he has had trouble with them, he claims that satisfactory service can be maintained in his particular locality, as he considers the question of the distribution of power and light an exceedingly simple one in his city, which is probably the only city which is so fortunately situated.

He has in all about thirty-two circuits. He states that he is on the right track regarding the placing of wires underground, and that the system such as he operates will run satisfactorily. The cables that he is using are guaranteed for three years. The trouble that he had with his first wires was mainly due, as far as he can ascertain, to the fact that the insulation surrounding the wires was not of sufficient thickness, and the main conduits themselves were not dry. He controls his own conduits exclusively.

Seventh: The writer has made some practical experiments and tests with cables under water; these were manufactured by two of the most prominent companies. The cables did not, however, work satisfactorily, lasting, as they did, from three months to one and a-half years. He lays the cause of failure to the effect of water upon the cable, and the deterioration in the insulation of the wire. His opinion, based upon the tests he has made, is that he does not consider it practicable to place his conductors underground; considers that the difficulties are both electrical, mechanical and commercial; had exclusive control over such conduits as he used.

In summarising the results of the experiments in these cities, in one case only did the electric light company place its wires underground willingly; in all others they were forced to do so by the local authorities.

In only one instance have the experiments or practical workings proved satisfactory; the only other case that they did not report adversely being where the wires had only been in operation about forty days. The average voltage that we used on all the circuits tested was 1,893 volts; the current was ten amperes; the average thickness of insulation over wires was 9·32 of an inch; and the average length of cables tested in each case was about 4,600ft.

In considering the second class of answers, namely, those who have not yet made any extended practical test, their answers have been directed mainly to the last four questions, the first two of which relate to action by the municipal authorities, and the last two consider the practicability and the difficulties of placing wires underground. In very few of these cities have the municipal authorities yet taken any steps toward action upon the matter, having been delayed in awaiting the solution of the underground question in other cities.

In answer to the question, asking them if they considered it practical to place their conductors underground, 104 have replied that their opinions, based upon tests that they have seen and such information as they have been able to obtain, both in this country and abroad, is "that it has not been practical to place the wires conveying high tension electric arc light currents underground."

Two have answered that they considered it practical to do so, but state that at the present time they have no wires underground.

In answer to the question, which asks their opinion regarding the greatest difficulties to be met with in considering the placing and operating of underground wires, they all unite in the opinion that the difficulties are mechanical, electrical, and commercial.

They consider that the question of obtaining a satisfactory conduit has not been properly solved, and that even if that should be solved in the future we cannot even at this time obtain a satisfactory insulation for the wires that will not deteriorate within a few years, and become perfectly useless as an insulator when subjected to the action of steam, water, and gas. The great difficulty of making connections for buildings and lamps, and the absence of any satisfactory system of subsidiary conduits, is considered by all as a bar to successful operation, as the difficulty of drawing in cables without abrasion to the insulating covering, even with the most careful handling, is very great.

The commercial objection is considered a very great one, as not only is the first cost about eight times heavier than that of an overhead system, but the repairs to the cables due to the deterioration of the insulation and other defects caused by mechanical or electrical deficiencies would be very much heavier than the expense of operating and maintaining overhead systems, and that the prices at which they are now furnishing the electric light would have to be very materially increased to meet these extra and very heavy expenses. A system of tunnels through all the principal streets is considered to afford the only means for the solution of this problem.

The committee also sent a letter asking many of the questions that were sent in the circular to all of the electric underground wire companies, and in response received quite a number of communications from the cable companies. Most of them said that at the present time they were unable to give any information in regard to underground wiring, as they have had very little experience with wires for that purpose, but that they do not doubt that in the future the state of the art will permit of the wires being placed underground. Other companies reply that the wiring of their system that has been used for underground purposes has been for potentials under 2,000 volts, and that they have met with entire success with potentials of a system with 1,000 volts. And they do not anticipate in the future that they will have any trouble in furnishing wire to meet the requirements of the electric lighting companies, but at the present time they have not yet done so. They unite in stating that they think that the question of insulation of high voltage of currents should be solved by the using of good, durable, thick insulation. Their experience in conduits has been, that they do not want creosoted wood, but would prefer to have their wires buried in the ground, or under water, and would recommend at the present time that single conductors should be used. They seem to be about evenly divided on the question as to whether lead-covered cables should be used for underground purposes."

LEGAL INTELLIGENCE.

King, Brown and Co. v. The Anglo-American Brush Electric Light Corporation (Limited).

In continuation of the evidence of Mr. C. F. Brush, taken on commission in Cleveland, the witness's cross-examination proceeded as follows:—

Parts of the first edition of the Haddan patent referred, broadly speaking, to a shunt dynamo. The passages in the specification of 1878 referring to that were retained in the specification as amended, and disclaimed excepting claim 8, which was disclaimed and cancelled. *Q.* Do you in the passages so retained represent a shunt dynamo as part of your invention?—*A.* Most assuredly not as part of my invention intended to be covered and claimed by the present Haddan patent. Had I designed or intended the "simple-shunt" form of dynamo to constitute an embodiment to be com-

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prehended by the Haddan patent the eighth claim would not have been cancelled. I consider, and still consider, that the cancellation of claim 8 removed from the Haddan patent all pretext that the "simple-shunt" form of dynamo is intended to be, or is in fact, embodied within the scope of invention designed to be covered by that patent as it now stands. Whatever references to a simple-shunt dynamo that now appear in the Haddan specification remained simply as gratuitous suggestions or descriptions of that which the patent does not claim or cover, and which serve to more clearly and definitely indicate by contradistinction just what the patent in its present shape is intended to include and cover, namely, a compound-wound dynamo, so far as division 4 of that patent is concerned. *Q.* Was it known in 1878 that the system of compound-winding, or what is the subject of claim 7 in the letters patent of 1878 as finally amended and disclaimed, was applicable or useful in connection with electric lighting? When did this first become known so far as you are aware?—*A.* In 1878 the art of incandescent electric lighting was still in its formative stage, and had not reached the practical development which it soon after obtained. My invention of the compound-wound dynamo played no unimportant part in the practical solution of the problem of incandescent lighting. So far as concerned are electric lighting, I very well understood in 1878 the non-suitableness of the compound-wound dynamo for operating arc lamps. But upon the production of my compound-wound dynamo its application to incandescent lighting was apparent, and was recognised soon after. *Q.* Did you tell Mr. Swinburne, in May, 1882, in Cleveland, Ohio, that you did not think a constant-potential machine could be made, but that if he would take the responsibility of ordering the machines you would make them, or anything to that effect?—*A.* I do not remember ever making such, or substantially such, statements to Mr. Swinburne, and do not believe that I ever did. I may, however, have discouraged, and probably did discourage, the construction of the special machines he wanted, knowing that the commercial demand for them at that time had not become sufficiently large to warrant the time and expense that would be necessary to determine the relative proportions and details of construction. *Q.* Did you ever say to Mr. Swinburne, in May, 1882, that you had discouraged the construction of these machines, knowing that such construction would require considerable time in calculation, superintendence, and testing on your part, without leading to the construction of such machines at that time for commercial purposes.—*A.* I have no remembrance of any such conversation, either in substance or effect, and do not believe that it ever occurred. In 1882 I had the invention of the compound-wound shunt dynamo and its essential principles of construction and operation as clearly and distinctly in my mind as I have to-day, and could not have any reason for speaking in effect as the question implies. I had completed the invention of the compound-wound dynamo several years previously, and had filed my application for my United States letters patent there on March 11, 1878, wherein I had fully illustrated and described the compound-wound dynamo. Upon this application my American patent of July 22, 1879, was granted. I was fully prepared in the early part of 1878 to construct a compound-wound shunt machine, and could have made one then without any extraordinary consumption of time in calculation, superintendence, or testing on my part, and with a certainty of making a commercially acceptable machine. As a matter of fact, before the early part of 1878 my licensees in America were making and selling my compound-wound dynamo for electro-plating purposes, and a number of them were then already in very successful commercial use. Referred to a sentence in Haddan's specification, witness said that using the terms "pure shunt" and "simple shunt" synonymously he found that both a simple-shunt and compound-shunt machine were referred to there. A workman with Haddan's specification might hit constant or approximately constant potential in his first construction of field coils, or being experienced in the construction of series machines of the same type he might be able to calculate or gauge the proper proportions, as he did himself. He could not fail by following the specification and drawing to make an approximately constant potential machine, and a machine much better adapted for the purposes requiring constant potential than a series machine. Asked if simple-shunt machines were used for electro-plating prior to Haddan's patent of 1878, he answered that, judging from the statement made in the specification of the Clark patent of 1875, he should say that a simple-shunt machine had been attempted to be used, or, at least, suggested, for "electro-metallurgical" purposes, which evidently referred to electro-plating. *Q.* Had you or anyone else any knowledge of incandescent lighting at the date of Haddan's patent?—*A.* Strictly speaking, yes. Incandescent lighting, however, had not reached its practical or commercial development and introduction in 1878. In answer to other interrogatories, he said that it was of great importance that the polarity in machines used for electro-plating should under no circumstances be liable to change. In arc electric lighting it was important that the dynamo should not change its polarity. In incandescent electric lighting, however, the lamps would burn as well with the dynamo current flowing in one as the other direction. But for incandescent lighting there were other essential requirements that necessitated the employment of a dynamo whose construction is of such a character that under ordinary and normal conditions its polarity is not at all liable to reversal for whatever purpose it might be used, whether for operating lamps or otherwise. The compound-wound machine was not more liable to change polarity when used for electro-plating than the plain shunt machine. *Q.* Is Varley's description of how he prefers to employ a part of the electricity to maintain the magnetism of the soft-iron magnets not a description of series-shunt winding?—*A.* I cannot so understand it. Varley distinctly states: "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light." In a compound-wound dynamo all of the electricity developed by the machine, and not part of it only, energises the field-magnets. *Q.* Is it possible to make a compound-wound machine so as to give an approximate constant potential, while at the same time doing work in the shunt circuit external to the machine?—*A.* Not if the external working in the shunt-circuit is variable in amount, or involves a variation of resistance in the external part of the shunt circuit, or involves the opening of the shunt-circuit at intervals, however brief such openings may be. *Q.* With regard to compound winding, state what are the differences between the system disclosed in Haddan's patent and that disclosed in Varley's patent?—*A.* I have already repeatedly stated that I cannot possibly understand that Varley disclosed or described or suggested compound winding as viewed in the light of the state of the art at the date of his specification. I still maintain this opinion, and therefore cannot discuss the differences between Varley's construction and the compound winding disclosed in the Haddan patent, as this pre-supposes or assumes that Varley showed compound winding, which he does not. Replying to further questions the witness said that the two elements in Haddan's seventh claim were a shunt coil and a series coil. Such a shunt coil was not to his knowledge known before the date of Haddan's patent; and such a series coil was not, strictly speaking, known prior to that date. In 1878 the purpose of a shunt coil was not the same as that of a series coil. The same result could not be obtained in both cases. *Q.* In the subject matter of the seventh claim is there simply the addition of two methods of producing the same result, both of which were known or in use prior to the date of Haddan's patent?—*A.* Nothing of the kind. The subject matter of the seventh claim is a combination of elements and instrumentalities in a dynamo that, so far as I am aware, produced a radically new type among electrical generators. That claim refers to and covers a unitary device, and not two old methods in any sense; and this unitary device is a dynamo having distinctively peculiar and highly important and valuable functions and adaptabilities, neither attained nor approximated by any prior invention that has ever come to my knowledge. This machine satisfied wants that were widely felt long prior to the date of the Haddan patent—electro-plating for instance, and it went into wide and successful use promptly after its invention. It appears to me that this fact alone goes far towards convincing of the fact that whatever older methods might have been known or adopted their failure to receive the approval and acceptance that was immediately given the dynamo referred to in the seventh claim indicates conclusively that they were not only deficient or inoperative, but that they did not contain or approach the invention covered by the seventh claim. *Q.* What is the invention claimed in the seventh claim?—*A.* In a dynamo electric machine the wire helix E having a comparatively high resistance and kept in close circuit while the machine is running in combination with the magnetic wire or helix F as commonly employed, substantially as shown in Division 4 of the Haddan patent. *Q.* State what is disclosed in Haddan's specification as to compound-winding which was not previously disclosed in Varley's specification?—*A.* Everything. The Haddan patent definitely and completely discloses compound winding, whereas there was nothing in the Varley patent that disclosed it; but, on the contrary, all the interpretations that can be gathered, however dimly, from its vague, incomplete, and uncertain statements, and its drawings, taken as a whole, are entirely repugnant to the conclusion that Varley had ever conceived the idea of the compound-wound dynamo, and much less that he disclosed such an invention in his patent. If Mr. Varley in his patent had intended to disclose any idea of a compound-wound dynamo, or to increase any form or construction of such an invention, it is impossible for me to explain or to understand why he did not make such a fact at least remotely apparent in the specification and drawings on the claims of his patent. The drawings do not illustrate or suggest compound winding. The specification did not disclose it, and the claims do not in the remotest degree refer to such an invention, or to anything that would require a compound-wound dynamo, or suggest its desirability. In reply to the question—Was the only object of the seventh claim, as at 1878, to improve the application of electricity to electro-plating? he said that he had stated in the specification that "other useful applications of a permanent field machine will readily suggest themselves," and that he had had also telegraphy in mind. He had no doubt that Varley, when he said that "part of the electricity developed by the machine is diverted to maintain the magnetism of the soft-iron magnets," and again, that "in order to ascertain the amount of electric force which is being produced, &c.," meant identically the same thing in using the terms "electricity" and "electric force." *Q.* If in Varley "electricity" is held as equivalent to "electric energy," does Varley correctly describe compound winding?—*A.* Not correctly. The passage referred to would then read in substance, "Part of the electric energy developed by the machine is diverted to maintain the magnetism of the soft-iron magnets, and the remaining portion is used to produce the electric light." This would not correctly describe compound winding, because in compound winding not only is a part of the "electric energy" diverted to energise the field-magnet, but also a part of the remaining portion of the electric energy is used or absorbed for the same purpose, and to this extent, which is considerable, cannot be used to produce the electric light. I will add that I cannot accept as justified by Varley's specification the definition of the word "electricity" as being "electric energy," as the question provides. *Q.* Would a Varley machine, wound with series and shunt magnet coils acting together, be an infringement of Haddan's specification if made now?—*A.* I would be glad to answer this question definitely if I could determine to my satisfaction what sort of a machine a Varley dynamo is or was. If Varley should wind, connect, and use his machine in the manner customary with compound-wound machines, as such machines are at present made and used, I should say that such a construction would infringe the Haddan patent. But Varley does not appear to have done or indicated this.

Lord Trayner has fixed the hearing of counsel on the evidence for the 22nd May.

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THE CENTRAL LIGHTING STATIONS OF FRANCE.

This list of French central stations has been, in part, compiled from a Paper read before the Société Industrielle du Nord de la France by M. Aimé Witz, but has been enlarged and revised by our Paris correspondent.

Town.	System.	Output in horse-power.	Distribution.	Remarks.
Bellegarde	Edison (Low tension).....	80	Overhead	Water power
Tours	Gaulard-Gibbs transformers	300	Partly overhead and partly underground	
Roche-sur-Yon..	Thury (Low tension)	45	Overhead	Water power
St. Etienne.....	Edison (Low tension).....	190	Overhead	
Bourganeuf.....	Thury (Low tension).....	30	Overhead	
Dijon	Edison (Low tension).....	35	Overhead	
Coatigrach (Finistère) ...	High tension...	45	Overhead	Water power, accumulators employed after midnight
Compiègne	Low tension...	130	Overhead	
Nancy	Ferranti transformers	625	Concentric cables underground.	
Cité Bergère (Paris)	Edison (Low tension).....	800	Underground	
Palais-Royal (Paris)	Edison (Low tension).....	600	Underground	
Faubourg St. Martin (Paris)	Gramme (Low tension).....	125	Overhead	
Lyon	Société Alsacienne de Constructions Mécaniques (Low tension)	600	Underground	
Perpignan	Thury (Low tension).....	100	Overhead	
Bordeaux	Gramme (Low tension).....	50	Underground	
Rouen	Edison (Low tension).....	100	Overhead	
Le Havre.....	Edison (Low tension).....	—	—	In progress.
Toulon.....	Société Alsacienne (Low tension).....	1'0	Underground	
Montpellier.....	Société Alsacienne (Low tension).....	300	Underground	
Manosque	Thury (Low tension).....	50	Overhead	Water power

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

[Our usual American correspondence has failed to come to hand this week, but the following paragraphs were crowded out of our last issue.]

The annual meeting of the stockholders of the Westinghouse Electric Company was held at Pittsburg on the 12th ult. The business during the past year has been prosperous, and the earnings up to December 31 were more than sufficient to pay the usual quarterly dividend of 1½ per cent. During the past year the company has acquired by lease the control of the Consolidated Electric Light Company and the Sawyer-Man Electric Light Company, and the company now owns $1,235,000 par value of the capital stock of the Consolidated Company, the capital of which is $2,500,000. The earnings from these two companies for the first quarter have been sufficient to pay the rental. In November, 1888, the company acquired the capital stock ($135,000) and outfit of the Waterhouse Electric and Manufacturing Company, together with valuable inventions. In January an agreement was entered into, as you have already noted, with the principal owners of the United States Electric Lighting Company, whereby this company purchased seven-fifteenths of the stock of that company (capital, $1,500,000), and whereby that company was leased to the Westinghouse Company. By the acquirement of the control of the Consolidated and United States Companies, the Westinghouse Company "has secured a favourable position with reference to patents, having now the exclusive rights under the Sawyer-Man patents and numerous other valuable inventions." The orders received for central station apparatus since the 1st January aggregate a capacity of 50,000 16 candle-power lights. The number of lamps sold by the Sawyer-Man Company in January was 92,000, while the United States Company for the same period sold 50,000 lamps. The three lamp factories are now capable, with the present machinery, of producing at least 81,000 lamps per day.

Some time ago I alluded in this letter to the remarkable growth of the electric railway business of the Sprague Company, and the electrical papers this week give illustrations of three more lines lately completed by that company, those at Brockton, Reading and Wilmington. The Brockton road is four miles long, and operates four cars. One of the preliminary tests through which the road passed most successfully, was made by bunching all the cars at a point on the road farthest distant from the power house, and starting them all up at once. Although the power for all the cars was transmitted between two or three miles, the cars started off promptly, moving rapidly, and showing that the entire power can be easily transmitted and applied even at the farthest end of a line, and that the load upon the dynamos can be varied from zero to a maximum without any detrimental result to the electrical apparatus. The Reading road has a single track, and is about two miles long. It has been in operation two months, and is giving great satisfaction both to its directors and to the public. The Wilmington line has been working for eight months, and the best proof of its success is the fact that the directors have ordered an additional number of cars. The president of the company pronounces the system a complete success, and is of opinion that it is not only the most economical mode of running street cars in suburban districts, but that it is markedly cheaper and more efficient than horse-power. It has secured the favour of the public by its smooth and rapid motion, and has received commendation on all sides. The Sprague Company has just made another important installation on the electric branch of the West End Road at Boston, and at an inspection of the line on February 5 most of the prominent street railway men of New England were gathered. The power plant consists of two Armington and Sims high-speed engines of 200 horse-power each and four dynamos of 80,000 watts capacity each.

In the meantime New York has been threatened with a revival of schemes for grid-ironing the city with a system of cable roads, and it seems likely that if anything can result from the influence brought to bear upon the Legislature at Albany the project may be put through. But it appears to meet with pretty strong objections from Mayor Grant of this city, who says that "the Bill in question now before the Assembly is inimical to the best interests of the community and assails public rights." Hence, it is not likely to find much favour with the public, which will, I think, soon wake up like their neighbours in Boston to the benefits to be derived from the adoption of electric power on the city roads. Although several notable demonstrations of the ability of the electric motor to do the work have been given in this city, New York is still very much behind, and ought to be setting a better example.

PARIS NOTES.

(FROM OUR CORRESPONDENT.)

March 13th, 1889.

The fall in the shares of the Société des Métaux, which I spoke of in my last letter, has since greatly increased, and the shares have at the present moment no marketable value at all. The copper monopoly may be considered as dead, much to the benefit of consumers of this metal in general, and of electricians in particular.

The Conseil Municipal has introduced a modification in the Cahier des Charges concerning electrical central stations. This modification relates to Art. 27, which has been modified as follows: "All the material, as well as lamps and wires, must be furnished

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by French firms, and manufactured in France." This decision, which cannot be disapproved of by any Frenchman, may give a check to the ardour of some of the *concessionaires*, who have, it is said, already treated with English and American electrical firms for the supply of their material. Up to this date only four of the *concessionaires* out of the six have deposited the required caution money of 300,000fr. Those which have done so are the Edison Company, the Marcel Deprez Company, the Société du Secteur de la Place Clichy, and the Popp Company. Up to now nothing certain can be said as to the systems these companies will adopt, but the systems employed by them will be probably as follows :—Ferranti transformers by the Marcel Deprez Company, accumulators by the Popp Company, partly Zipernowsky transformers and partly low tension by the Edison Company ; low tension by the Secteur de la Place Clichy. Nothing has been settled yet concerning the lighting of the Boulevards during the forthcoming Exhibition, though some decision will be arrived at by the Conseil Municipal in the course of next week.

In the provinces, Marseilles, Nîmes, Rouen, Avignon, &c., have their municipal bodies occupied with the question of the electric light, and if France felt some apprehension in accepting the new light when it first appeared, it will certainly not be long before it is at the head of this improvement in the private and public lighting. The last meeting of the Société Internationale des Electriciens was partly occupied by a lecture by M. Cance "On the Electric Lighting of the Magasins du Bon Marché." The total motive power amounts to 1,699 horse-power, with 799,000 watts available, if necessary. The ordinary lighting consists of 276 Cance arc lights, 84 Jablochkoff candles, and 3,000 16 candle-power incandescent lamps.

The illuminated fountains which formed so notable a feature of the Exhibitions at London, Manchester, Glasgow, and Barcelona will not be missing at the one in Paris. We do not intend to rest content with what has already been done, but hope to surpass all the beautiful effects hitherto shown. When the illuminated column of water displays its variegated colours in the evening all the surrounding fountains and water will be simultaneously lit up, and it is expected that effects unlike any yet seen will be obtained.

Some of your readers may perhaps like to know that full information with regard to the electricity meter competition can be obtained on application to the Secretaire Général de la Préfecture de la Seine, Paris.

A French Company, calling itself the Société Electro-Métallurgique, has just commenced the manufacture of aluminium alloys by the Heroult process. The works are at Froges (Isère), and are equal to a daily output of 3,000 kilogrammes of alloy. The current is produced by two dynamos, each giving 7,000 amperes and 20 volts. These dynamos are separately excited by a machine giving 350 amperes and 65 volts. The motive power is obtained from two vertical turbines of 300 horse-power each.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *March 13th*, 1889.

The Statistical Department of the Ministry of Commerce have published some interesting figures regarding the development of the Post and Telegraph Service in Austria during 1887, amongst which I note that the total length of the telegraph lines in Austria in 1887 was 3,847 kilometres, and 7,215,172 telegrams were transmitted, against 6,909,638 in 1886, an increase, that is to say, of 4 per cent.

Messrs. Siemens and Halske are actively pushing the completion of their Central Station in the Neubadgasse. They are also laying new cables, one from their Central Station through the Nagler and Irisgassy, to the Freiung, another from the corner of the Herrengasse and Kohlmarkt, through the Schaüflergasse, Ballhaüsplatz, Volksgarten, Burgring, Bellariastrasse, to the new Volks Theatre, which they are going to light up. Messrs. Egger and Co. have sold their glow lamp factory in Budapest to a company. The factory is to be refitted and to be made capable of an output of 6,000 lamps daily. The electric light installation in the Houses of Parliament is completed and works well. The new installation in the Rathhaus is progressing rapidly. I hear also that the Wiener Elektricitäts Gesellschaft have obtained a concession from the municipality of this city for the erection of a central station in the Kopernikus-Gasse.

The Electrotechnical Society of Vienna has just nominated a committee to draw up a set of fire rules for electric light installations ; the chairman of the committee is M. Ross, of the firm of Ganz and Co. Karlsbad, following the example of Marienbad, is to have a central lighting station. The plant will comprise two 50 kilo-watt machines, supplying 35 12-ampere arcs and 100 incandescents for street lighting, and over 2,500 incandescents for the hotels. Bilin (Bohemia) will shortly have its streets lighted by arc lamps. The electric railway scheme between Baden and Volsan it is expected will be sanctioned before long by the authorities.

NOTES FROM BRUSSELS.

(FROM OUR CORRESPONDENT.)

BRUSSELS, *March 11th*, 1889.

At its last sitting the Electric Lighting Committee nominated by the Administration Communale decided that the electric lighting of the town should not be undertaken by the municipal authorities. The first central station is to be worked by a company under a license from the town, which is to have the option of purchasing the undertaking at any time. Tenders will be received up to the 1st July next, and the bases upon which they must be drawn up are as follows :—Any system of distribution whatsoever may be employed, but it should be applicable to any purpose to which electricity may be put, and in any case it should permit the use of electric energy for motive power as well as for lighting. The station must be of such a size as to allow of double the original plant being installed. Amongst other information the tenders must explain how the contractors propose to maintain a constant potential, and must specify the nature of the insulation of the cables, the method of laying the mains underground, and of running the wires into the consumers' houses. The contractors must also give detailed information as to prices and method of charging. If a low-tension system of distribution is employed the tender must be drawn up on the supposition that the central station is situated at the north end of the Halles, with a second station serving the upper part of the town behind the Eden Theatre. If high-tension currents are employed, some ground near the gas works may be supposed to be the site of the central station. The staff of the undertaker will be paid by the town, and the undertaker must superintend the station in person, or he must delegate competent electricians to take his place. Finally, the accounts of the contractor, and everything relating to the working of the station, is to be under the control of the town.

The authorities have, it will be seen, taken every precaution to ensure for themselves a preponderating influence in this matter, so that should the experiment turn out a success, and affect the gas revenue, the municipality may be in a position to reap the advantage, and recoup itself for the diminution of income from the gas works.

The Houillères-Urries at Gilly have just put up a large electric light installation on the Dulait system. The lights are all above-ground, and comprise five 2,400 candle-power arcs, eight 1,600 candle-power arcs, and about 100 16 candle-power incandescents. The current is supplied by a Dulait dynamo, giving 350 amperes at 110 volts, and running at only 350 revolutions per minute.

CORRESPONDENCE.

THE DAVEY-PAXMAN ENGINE TRIALS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In your article on the Society of Arts trials of motors for electric lighting you remark, in regard to the engine trials, that the results arrived at with this engine confirm in a remarkable degree those obtained by a similar engine by the same firm at Newcastle. As this is a matter of scientific interest, allow me to point out that you have been misinformed.

By reference to the data given below, taken from the Society of Arts *Journal*, February 15, 1889, page 235, and from *Engineering*, November 18, 1887, page 518, it will be seen that the Newcastle supposed results differ from the recent experiments not by 1 or 2 per cent., but by more than 10 per cent.

The recent careful trials of the compound non-condensing engine may be taken as not only correct but as showing almost the best results attainable with that form of engine of that size and design and under the conditions of trial. As such they are of great practical value.

There is a marked advantage with 190lb. as compared with 120lb. boiler pressure.

It is reasonable to suppose that the engine of 1889 had some structural advantages over that of 1887, and it certainly had the advantage of higher boiler pressure. It is, therefore, reasonable to suppose that the engine of 1887 must have used slightly more water and coal than that of 1889.

In the table below the water per brake and indicated horse-power for 1887 are calculated from data given in other parts of the R.A.S. tables :—

	1887.	1889. (mean.)
Water per indicated horse-power	18·7 ...	20·51
Water per brake indicated horse-power	21·0 ...	23·3
Coal per brake horse-power	1·85 ...	2·04

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Both these sets of figures cannot be right: those for 1887 are from 11 per cent. to 12 per cent. better than those for 1889.

For my part, having had the honour to know personally Prof. Kennedy, Prof. Barr, and Mr. Halpin; having used the Appold brake for many years, and also having made many experiments with compound non-condensing engines, I accept the recent experiments as correct, and reject those of 1887 as impossible under the conditions and erroneous to at least the degree above named.—Yours, &c., WILSON HARTNELL.

[Mr. Hartnell's letter calls attention to a question of some interest, but the importance of the figures he mentions in correction of the remarks we made depends on the view taken as to the similiarity necessary in two sets of figures to permit the one to be considered confirmatory of the other. The Paxman engine in the Society of Arts trials at South Kensington used 2·01lbs. of coal per brake horse-power. At Newcastle a similar engine used 1·874lbs. The approach to similiarity in these figures would not of course, if taken alone, be considered as confirmatory of the same degree of accuracy in the methods of obtaining them, but we must point out that the coal used at South Kensington contained but 84·5 per cent. of carbon, as against 88·4 per cent. in that used at Newcastle, representing a difference of 551 thermal units per lb. of coal. The hydrogen seems to have been the same in both coals, but nitrogen and ash were both greater at South Kensington. The 2·01lbs. of coal used in the Society of Arts trials thus gave off at least 1,101 units less than the coal used at Newcastle. Of the difference of 10 per cent. between the 1·874lbs. of coal used at Newcastle and the 2·01 used at Kensington, then, the difference in the quality of the coal thus explains nearly one-half. Another important difference is the fact that while the steam jacket was used at Newcastle, it was not used at Kensington. We have always believed that engineers were agreed as to the value of a steam jacket, and that a gain by its use of 5 per cent. is a modest view of its value. Taking these facts into consideration, we are still of opinion that there is a striking similiarity between the performance of the engine at Newcastle and that at Kensington. We do not attach much importance or any to the discrepancy between the quantity of feed water used at Kensington and that used at Newcastle, because the jackets in the latter engine drained back into the boiler, so that it would be difficult to say what quantity of water was evaporated.

The steam pressure used at Newcastle was 150lbs. per square inch, not 120lbs., as mentioned by Mr. Hartnell. We were not aware that Prof. Barr and Mr. Halpin were concerned in the trials at South Kensington, but we quite agree with Mr. Hartnell that the 1888 (not 1889) trials yielded figures which will not give rise to the complaint which was made concerning the comparative tests at Newcastle.—ED. *E.*]

ON THE DESIGNING OF CONTINUOUS-CURRENT DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 487 of *The Electrician* Prof. Jamieson, in speaking of the magnetic resistance of the armature core, gives the following formula:—

$$R_a = \frac{L_a}{S_a}.$$

Where R_a = magnetic resistance of armature core, L_a = mean average length of armature core magnetic circuit in inches: if there was only but one path instead of two, we should have to multiply by the coefficient 2, as in equation (IV.), but

$$\frac{2\,L_a}{2} = L_a.$$

S_a = cross sectional area of armature core in square inches = twice radial depth × length of armature core.

Should this formula not be

$$R_a = \frac{2\,L_a}{S_a}.$$

Then further on, on page 489, in applying this formula to an example of a given dynamo of gramme type ring armature he says:—

$$R_a = \frac{15}{25} = \cdot 6,$$

where radial depth of core = 1·75 inches, diameter of core = 10 inches, length of core = 9 inches, L_a = 15 inches, S_a = 1·75 × 9 less 20 per cent. for insulation and air spaces = 25 square inches.

Should not $$R_a = \frac{2 \times 15}{25} = 1 \cdot 2.$$

Of course this is assuming that the magnetic resistance remains constant for any degree of saturation of the core, which is not the case; also, that the Kapp co-efficient 2 is sufficiently near the mark for soft wrought iron, which is doubtful, as there must be considerable variation in this co-efficient depending upon the nature of the iron used.—Yours, &c.,

Edinburgh, March 11, 1889. WM. GEIPEL.

INTERCALATING APPARATUS FOR PORTABLE INCANDESCENT LAMPS.

In the annexed engravings we illustrate an improved switch or "intercalating apparatus" brought out by Messrs. Mix and Genest, of Berlin. The apparatus hitherto in use has the disadvantage that the switches must either be turned (screws or bayonets), or they cannot be turned at all, because the contact pieces are not centrally arranged. The idea of arranging the two contact pieces of the switch in the form of concentric tubes in and around the switch contributes to give the apparatus a solid construction. The contact pieces are connected by soldered copper wire with the

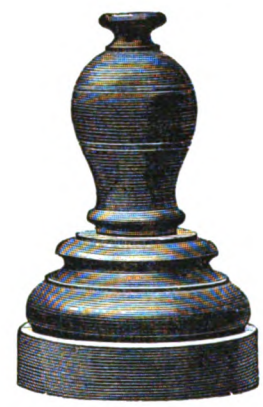

FIG. 1.

segment-like binding screw in the handle. Fig. 1 shows the apparatus complete, while Fig. 2 shows the construction. The contact

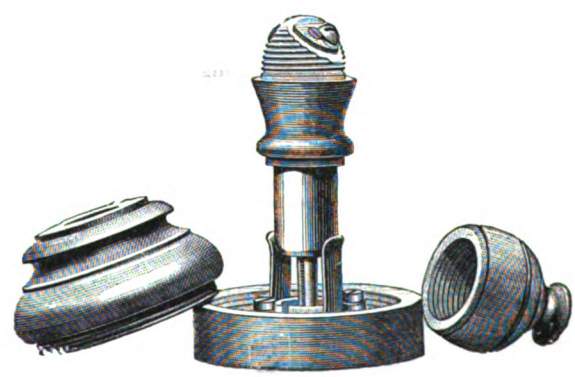

FIG 2.

pieces of the connecting box are suitably arranged, and the two spring-plates and the joint are stamped out of one piece and fastened by one binding screw. The spring pin being split with a conical top, when pressed into the interior contact tube completes the electric circuit with the ground plate fixed by the second binding screw. Besides its suitable and solid form, this apparatus has the advantage that the intercalation of portable glow lamps can be easily effected in the dark. No turning being necessary, the possibility of injuring the wire at the joining points is very remote. The apparatus can either be fixed on the wall or on a gas tube hanging from the ceiling.

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COMPANIES' MEETINGS & REPORTS.

The Anglo-American Brush Electric Light Corporation (Limited).

The eighth ordinary general meeting of this Corporation was held at the Cannon-street Hotel on Wednesday, under the presidency of the Right Hon. Lord Thurlow, F.R.S.

The SECRETARY and MANAGER (Mr. Emile Garcke) read the minutes of the last meeting, which were confirmed and signed as correctly entered. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: I will now proceed, gentlemen, without further loss of time, to say a few words, as is customary on these occasions, explanatory of the terms of the report and of the figures which are contained in the balance-sheet. I think, however, on the present occasion that the report is so full and exhaustive, and the figures so satisfactory, that it will not be necessary for me to detain you very long at this stage, at any rate, of our proceedings. At a later stage we shall be happy to give you full explanations on any point that you may very naturally raise and desire further information upon. But I am bound to say that I think, contrasting this report and balance-sheet with those of the previous four or five years, it will be difficult for any of the shareholders to entertain other than a feeling of satisfaction and great hopefulness for the future. This has been undoubtedly a year of progress, and very marked progress, in all electrical affairs. To what extent the improvement is due to the Act of Parliament that was passed last session you must each of you judge for yourself. My own impression is that the advance in electrical science, and in its application to domestic affairs in almost every shape and form, is due to a very large extent to the passing of that Act of last year, amending Mr. Chamberlain's well-known Act of 1882; and I am glad to be able to say that I believe that Mr. Chamberlain himself heartily approves of the action of Parliament last year, and recognises the advantages that have ensued from it. Well, gentlemen, that being so, I think I need not detain you at much greater length on that point, but it may be interesting to you to know that at the present moment there are no less than twenty-one central stations established, or in course of progress, in the metropolis alone. You all know that in every considerable town in England the same thing is taking place, and not only in every considerable town, but in many second and third class towns throughout the country. Well, in a very large number of these enterprises we are interested not only as manufacturers but in other ways. Under our Articles we are, as you know, entitled to participate in this kind of undertaking, and although we proceed with the greatest possible caution we deem that it is advisable, seeing that their interests are identical to our own, to embark occasionally in and assist these various local enterprises. There is one, for example, that I desire to mention in which we are embarked, and in which we take the very greatest interest. Some of your Directors are Directors of the company, and I am thankful to say that it is making very rapid and satisfactory progress. I allude to the Chelsea Electricity Supply Company. We have got a large area to supply, and we have made most favourable contracts not only with the consumers but with those who are manufacturing jointly with ourselves the plant that is supplied, and I venture to say that the Chelsea Company will be a model in every way to those which are hereafter established. We have proceeded with the very greatest care in the consideration of the details requisite for the undertaking. Of course central lighting installations and central lighting stations are still to a certain extent matters of novelty. A certain amount of experience has undoubtedly been gained, but a great deal also undoubtedly remains to be done in the way of ultimately ascertaining what is the best form of building, the best type of machinery, engines and various other matters. All of these matters have received the most careful attention that we have been able to give to them. Anything that the Chelsea Electricity Supply Company has done will be a model of what such a station ought to be, and will no doubt give general satisfaction over the large area which it will very shortly light. At Bournemouth we are proceeding on a different system. At Chelsea the system that we have adopted is to use underground mains and accumulator stations. At Bournemouth we use alternating currents and overhead mains, which, in a comparatively rural district like Bournemouth, the light being used economically, have certain advantages in some cases, the distances being longer perhaps and the lighting not so continuous. These may be considered, and are justly considered, as rival systems of lighting. They are both receiving our attention. We have plant specially contrived and manufactured in our works which is adapted to both these systems, and I think I may say it without any fear of contradiction that there is no company in London or on the Continent that can supply the plant for either of these purposes which we can at Belvedere-road Works. Before I turn to the figures, about which, of course, I desire to say something, there is another subject to which I would make some allusion—very unwillingly, however, as I do not like to discuss a matter before the law courts; but I think you may fairly expect, and will expect, that I should say something with reference to the pending litigation. Of course the pending litigation is a very important matter. You may be quite sure it has never been absent from our minds during the past twelve months. At the same time you must not overlook the fact that the exact character of that litigation is not so important to us as it is to our antagonist. What we have at stake represents barely a tenth of our business. What the Edison and Swan people have at stake represents the whole of their business. At any rate there is a monopoly. Therefore I say that we can regard this matter with more calmness, perhaps, than our antagonist. It is not a matter of vital importance to us. We can get on without making lamps. We have another very large business, which is increasing by leaps and bounds, and which I venture to say in the course of 18 months or two years will surprise you all. For that reason I myself—and I think I can speak for every one of my colleagues—regard this litigation without any anxiety. Well, there is another reason why we can regard that litigation, I think, without overwhelming anxiety, and that is that we are confident in the justice of our cause, and we have very considerable confidence in the final issue. Of course litigation is an unpleasant thing to be connected with, and I can say from my own experience that it is a thing that I am absolutely unacquainted with. I have always made terms as to any matters personal to myself with any gentleman who attempted to get me in any way into litigation, and I should always pursue the same course in affairs connected with any company in which I happened to have a voice. But the present case is an exceptional one. We were met by people who contested the value of patents for which you paid a very large sum. We could not act according to what might have been our desires and wishes if it had been a private matter. We took the opinion of the best counsel, and that opinion was that we had a good case, and that we ought to fight it to the utmost. We have fought it as far as it has gone, and the result has been one way in one court and the other way in another court, and we are now in a perfect see-saw. The uncertainty of the law has long been a proverb, and it has been well exemplified in this case. The judgment of Mr. Justice Kay was considered at the time to be a very good decision. The case, however, went to the Court of Appeal, and his judgment was reversed. We have now notified our intention of taking it to the House of Lords, which is the highest court of appeal in the country. I do not know that when we get the decision of the House of Lords it may be final in this case, for reasons that I need not enter into now. At any rate, we felt that we had no alternative but to stick to our guns and go to the House of Lords. My own personal feelings are always in favour of making terms with your enemies while you are in the way of meeting them, and the Board has never neglected an opportunity of approaching the opposite side in the most conciliatory spirit, and with every desire to meet them half way, or as far I am sure as any gentleman in this room could desire. I am bound to say that our antagonists have not shown the same desire to do so, or at any rate the same conciliatory feeling. On the contrary, they have manifested a desire to continue this suit, and to really put us—if I may use the expression—to every inconvenience in their power. They may be all right, and justified in a thing of this sort, their position being, as I said before, different from ours. The law-suit being a vital one to them, it is hardly possible for them to approach it with the same calmness and independence as we can ourselves. However, I can assure you that while we have deemed it our duty to take this matter to the House of Lords, still we are open to be approached by the Edison and Swan people at any moment. We are willing to make terms with them so as to save your interests and to save your honour in any reasonable way that can be suggested, and I am not without hopes that before the interval which must elapse before this case can be heard in the House of Lords that something may be done in the way of arriving at a conclusion satisfactory to both parties. Beyond that I need say very little on that point. We have one other case pending at present. It is the case against Messrs. King, Brown and Co., Edinburgh, in reference to the compound winding. You know that we have a claim to have the controlling of the patents for compound-winding of dynamos. That has been admitted by all the English makers, and they are now paying us a royalty which amounts to a nice little income to us. But the firm I have mentioned have contested that claim, and have carried the matter to law, and the case is still pending. Under these circumstances I will not depart from the proper rule of not expressing any opinion on the merits of the case beyond what I have said. Now, I think you will permit me to turn to the accounts, which are as satisfactory as the report. Indeed, one cannot be satisfactory without the other. You will have noticed that these accounts and report have been accompanied by a diagram. This is somewhat unusual, perhaps, but we considered that it was perhaps the readiest way of bringing the facts to the comprehension of the shareholders—to show to what an extent the volume of business has increased, to what an extent the gross profits have increased, and to what an extent the general charges have decreased or remained stationary. I think that that document is a very remarkable paper. You will see that in the five years from 1883 to 1888 the volume of business has increased from 100 to 307, or over 200 per cent. in five years. You will see that during the same period the gross profits have increased 242 per cent. That I think is very remarkable, and I think I can fairly challenge any electric lighting company in the world to show similar results. And we have still one strong feature to dwell upon, and that is that the general charges have hardly increased at all—have not only not increased in the same ratio, but have, if anything, shown a tendency to decrease. That can be only due to one thing—to improved management. Economy has been introduced by our able manager, Mr. Garcke, into every branch of his administration. Our general charges have fallen from 100 to 65 per cent. I challenge any other electric lighting company in the world to produce an equally satisfactory diagram in the last five years' working. To turn to the profit and loss account for this year, you will see that the gross profit on the year's transactions and trading amount to the very respectable figure of £23,049, a result which I think very encouraging. To this we have to add the balance carried forward from last year of £2,562, making the available balance £30,612 carried to general account. I think I ought to point out that the standing charges show only an increase of 7 per cent., while the business has increased 50 per cent. during the last 12 months. Turning to the balance-sheet you will see that the share capital has been increased by the issue of 1,160 new shares. Those shares were issued for the purpose of increasing our working capital, which, as I think you may well imagine, we had every desire to do by every legitimate means, to enable us to undertake the large contracts which are daily being placed before us, and which we naturally are loth to send away to swell the business of our competitors. When I speak of our competitors in the trade, I think it may be interesting to you to know that we have not

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had all to ourselves this prosperity and increasing prosperity of electrical business. If you consult "*The Electrician*" *Electrical Trades' Directory*,* you will find that in 1883 there were only 57 electrical engineers carrying on business in the City of London. You will find that in 1885 that number had increased to 101, and by 1887 it had increased to 156, and by 1888, you will find that it has advanced to 260. In six years the number has increased therefore from 57 to 260, so that we have not had the field to ourselves in London and the country, and when I say London and the country the difference is not very material, because a very large number of those country houses have also their London establishments. Firms in Manchester, Birmingham, and other large towns have generally their London houses as well. No doubt the competition will be increasingly severe, but when you regard what we have been able to do during the last twelve months, I think you need not despair of our holding our own in this industry in the future. If you turn to the creditor account of our balance-sheet you will see the patents practically standing at the same figure. They are slightly raised by additional patents which it has been our duty to take out, and by certain other charges incidental to the up-keep and maintenance of our patents and for the purpose of making them more valuable. From time to time it is possible to improve the patents by the expenditure of a small sum of money, and we should be blind to our own interests if we failed to avail ourselves of those opportunities as they occurred. That accounts for the trifling increase at which our patents stand at the present day. I said last year that I considered these patents stood at a low figure in our books, and I challenge any electric lighting company to show patents of equal value standing at so low a figure. I do not know that I need deal with the other accounts. Property and stock have been valued and stand at about the usual figures. We are owed, you will be glad to see, for work done over £46,000, that is, after deducting a certain margin for what are called bad debts; but I am glad to say that we make very few bad debts. We have had considerable experience in this, and we find that our estimates have been remarkably well realised. The present debtor balances due to us are £48,531, whereas we owe our creditors—trade-people and others—only £22,120, which is a highly satisfactory state of affairs. There is a suspense account which is the next item. That is for charges and expenses in connection with litigation. We considered how to deal with that, and consulted our auditors and legal advisers, and we came to the conclusion that it would be manifestly unfair to put that, while the law cases are still *sub judice*, to profit and loss account. It may turn out that the expenses will be largely paid, if not entirely, by the other side; but, on the other hand, it may happen that we should have to bear the brunt of the expenditure ourselves. There is an element of uncertainty about the subject that makes it necessary to deal with the item in this way. Against it, however, on the other side you will see provision account of £17,816, which is practically able to meet it should the worst come to the worst. That provision account is not represented wholly by money in the bank at the present moment. It is employed in our business. It is represented partly by stock, partly by plant, and partly by some of those debtor balances which are due to us from our customers. It is a satisfactory feature of these accounts to know that we have made provision for the worst that can happen supposing our anticipations are not fulfilled. Therefore it is not necessary to allude further to them. I do not know that I need trouble you at the present stage of the proceedings with any further remarks than to say that I consider that the result which has been achieved has been achieved by the continuous and united efforts of your officers, and in some directions by the enhanced efficiency, combined with economy, which not only the Board, some of whom take the greatest interest in and have the greatest technical knowledge of your affairs, but your general manager, Mr. Garcke, your superintending engineer, Mr. Raworth, your consulting technical adviser, Major-General Webber, and Mr. Sellon and Mr. Mordey, your electricians, have shown. To every one of these gentlemen your thanks are due for the results achieved.

You stand to-day with a realised profit equal to 5 per cent. dividend on the whole of the share capital of the company. It remains for you to decide this morning what you will do with the money, whether you will put it in your pockets as a 5 per cent. dividend for the whole of the twelve months or whether you will adopt the more prudent course which we undoubtedly recommend of leaving it in abeyance until the litigation is over. I have no doubt in my own mind that that is the wisest policy to pursue. It is the course that has been followed by our opponents, the Edison and Swan. They had a large balance of profit in their last year's books. They did not distribute it among the members. They held it in abeyance to meet eventualities. I think it would be unwise for us not to take the same prudent course. But if you should differ from the feelings of the Board on this point, it is undoubtedly within your option at the present moment to have that money as dividend, and divide the profit of £12,885 which stands to your credit. I have only one thing more to say, and that is that this business has increased, and is increasing very rapidly. I consider that we have overcome our difficulties of manufacture. We have undoubtedly further improvements and economies to effect. It is impossible to go on manufacturing from day to day without perceiving opportunities of manufacturing under more economical circumstances. We might follow the example of some of our friends, and take our works into the country, where labour, and coal, and other things are considerably cheaper, but then there would be the expense of removing and other drawbacks. We may pursue that course a little later. For the present we are satisfied to remain where we are, because while there are some objections to carrying on business in London there are incidental advantages. No doubt visitors from the Colonies with whom we do business feel it a satisfaction to see our works and the class of our machinery without the necessity of going into the country, and therefore it is much more convenient and remunerative to us to give them that opportunity instead of our having to take them into the provinces. I feel that by having our works in London we obtain orders—many of them large ones—which we should not obtain if our works were situated 100 or 200 miles from the metropolis. For these reasons a move into the country is not to be lightly undertaken, but it is a subject that we have been carefully considering, and we shall continue to do so. What I was coming to, however, is this—our business is increasing, and it is equally necessary that our capital should increase in a corresponding manner. We have got every shilling in the business that we are able to put into it. We have got this provision account in it of £17,816, we have got a certain amount of £12,885 in it, and we have got nearly £10,000 at the bank. Of course, you see, we owe our creditors £22,000. It might be possible to increase the present figure, and carry on a larger business with much greater liabilities. But you know what that means. To carry on the business remuneratively in the future, and to be able to watch its growth with equanimity, and to derive the exact and proper advantages from it, it will be necessary for us and for you sooner or later to largely increase our capital. There is another reason why that is necessary. Look at those other companies that are doing business in the same way—two or three lighting companies that have been recently formed in London with their millions of capital, such as the London Electricity Supply Company, and one or two others that I need not mention. You know how they go to work with a million or two of money. They have the means of raising that capital, and no doubt if we are to compete on fair terms or equal terms with these companies in the course of time, we must have our millions too. We have not seen this thing going on without seeing the necessity that would naturally arise if it proved profitable (and we have proved that to a greater extent than our competitors) of increasing the capital, and when the time comes, and it will be before long, when we shall have to go to the public for an increase of capital, I am quite sure that there will be a large number of gentlemen who will respond to our demand. I have nothing to add to what I have said except to thank you for your continued confidence in myself and the Board with which I have the honour to be associated. We shall continue to the best of our ability to work for you as well as we can, and we hope to justify the continuation of that confidence which has been hitherto extended to us, and without which I feel, for one, it would have been impossible for us to have brought this business to the satisfactory position it now occupies. I beg to move—

"*That the report of the Directors and statement of accounts to the 31st December, 1888, now presented to the shareholders, be received and the same be hereby adopted.*"

Mr. JOHN SCUDAMORE SELLON (the Vice-Chairman): Gentlemen, in seconding the resolution which has been put before you it will be unnecessary for me to amplify in any way the remarks of the Chairman, in which he has so fully referred both to the prospects and to the general business of the Corporation. From those remarks you will, I hope, have arrived at the conclusion that a really substantial improvement has now taken place in the prospects of the electric lighting industry, and that, so far as our Corporation is concerned, we are certainly not in arrear of those developments. I beg to second the resolution.

Mr. WEIR thought the shareholders had reason to congratulate their noble Chairman for his successful efforts in Parliament. With reference to paragraph 8 of the report, with respect to the establishment of a better understanding among the various electrical manufacturers and contractors, he hoped that did not mean that the price of electric lighting was to be increased, because the gas companies would no doubt like to find the electric lighting companies allying themselves together to keep up prices. Their object should rather be to keep prices as low as possible in order that they might be able more successfully to compete with gas. The gas companies were making reductions all along the lines. The report stated that "the royalties now received constitute an important source of revenue." It might or might not be convenient to state the amount of royalties actually received; he would leave that to the decision of the Board; but if not inconvenient it would be interesting if the shareholders could be supplied with the information. He was very glad to hear from the Chairman that the Board were anxious to compromise wherever there was an opportunity of doing so, for in matters connected with patents one could not show too conciliatory a spirit. Of course, the Directors had been advised to contest the matter; but lawyers usually gave advice of that sort. He trusted, however, that the Board would compromise the matter if they could do so without sacrificing the interests of the shareholders. He thought it would be unwise to distribute any portion of the profits in hand at present.

Mr. CURRIE: Is there any objection to informing the meeting the period at which the appeal to the House of Lords is likely to come off?

A SHAREHOLDER: I have the misfortune to be a shareholder both in this Company and in your opponent, and I may say that I heard the Chairman of the other Company make almost identically the same remarks that our Chairman has made to-day. He was anxious, he said, that the matter should be settled without litigation, and yet this case goes on.

The CHAIRMAN: If there are no more questions I will endeavour to answer the few that have been put. There is no difficulty about answering them at all. With reference to the compound-winding royalties, of course they appear in our accounts, and they come to a substantial figure; but it would not be expedient, as the action in Edinburgh is still pending, and the whole matter is still *sub judice*, for me to state the exact figure at which these royalties stood during the past year; but I can assure you that they stand at a very respectable figure, and at an increasing figure; and that we have very great hopes that they will prove a substantial source of revenue during the remainder of those patents. I hope the shareholders will excuse me not being more explicit in reply to what is a very natural question to know, exactly what those royalties stand at. I think you may take that as a prudent course to pursue. Then with reference to the figures at which the stocks stand in our accounts, it is very little beyond what the same time

[* This Directory is published at the office of *The Electrician*, 1, Salisbury-court, Fleet-street, E.C., and the (7th yearly) issue for 1889 is just published.—*Publisher's Note.*]

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stood at in our last year's balance-sheet, and there is an undoubted tendency in that item to decrease in size. You must recollect that the volume of business we are doing now in comparison with the volume of business we were doing last year or the year before is very much greater; but you wil find that the stock practically stands at almost the same figure. You must also remember that we do a great deal of business which necessitates the keeping of a large amount of stock on hand, for exhibition lighting for instance. We have done a successful general lighting in nearly all the great exhibitions of late years—the Melbourne Exhibition, the Glasgow and Manchester Exhibition, and other places. At Barcelona, also, we have been very successful, and we have one or two other places on hand. We expect to have a considerable slice of the Paris Exhibition next year; we have practically got a contract for a considerable slice already. All this entails having a considerable amount of plant ready to send out at a moment's notice to the Colonies or elsewhere. The plant does not deteriorate, and when it goes to the Colonies it very seldom comes back. In the case of the Melbourne Exhibition, I should not be surprised if none of it comes back. We have sold a great deal of plant already in the same way at Barcelona. We have sold a great deal of the plant that we have sent out to different places, but if we had not had it ready to send out, at a moment's notice almost, we should not have made a profit; but the item will, I think, always tend to show a decreasing figure relatively to the volume of the business we have to do, and in the meantime it only stands at cost price in our books. Then, with reference to when we may expect this case to be heard by the House of Lords, of course it is impossible to fix the precise date, although it will very likely come off in the course of four or five months. Still, it may not come off for twelvemonths. It depends upon the arrears of work in the House of Lords, which are not anything like so heavy as they used to be. It depends greatly on the parties themselves. If they desire a postponement for the purpose of prolonging negotiations there would, of course, be a delay. It is really impossible to answer the question, except by saying that it is bound to be heard practically within twelvemonths if it is heard at all. But I heartily share the hope expressed by two or three of the shareholders that it will not come to that at all. If it does, we are confident of the result; but we have every desire to compromise on fair and honourable terms; having regard to your vested interests, we cannot throw your property away; I do not think you would wish us to do so. If we did you could bring an action against us for so doing. While, therefore, we have every desire to be conciliatory, and are prepared to settle on some terms, we are not prepared to settle on any terms. It therefore remains for the other side to show an equally conciliatory feeling before anything can be accomplished. Up to this moment there has been much more desire to settle this matter in an agreeable and friendly spirit manifested by us than by our antagonist the Edison and Swan Company. Of course we never know what that may be owing to. Some people think they impress others more when they assume a sort of dictatorial tone; but we do not think that. We are honest, straightforward people, and we speak to Mr. Forbes as I speak to you. We have every desire to settle it; but he comes and says "We have no desire to settle it; we are sure that we shall win;" but I cannot believe, for one, that that does not cover a certain amount of anxiety in his own mind when I know what it means to them. I hope, and think it very likely, that finally we may arrive at a friendly arrangement with them. Beyond that I have nothing more to say, except that I cordially hope it as much as any of our shareholders.

The motion was then put and carried unanimously.

Mr. SELLON: Gentlemen, I beg to propose the election of two directors in the place of those retiring, and the names that I will put forward are those of the Right Hon. Lord Thurlow and Colonel Steuart. Lord Thurlow's name in connection with electric lighting is, as you all know now, a household word, with which is connected the Electric Lighting Act which we so ably pioneered through the House of Lords and then through the House of Commons last year, and without which we should still be in a "slough of despond." Colonel Steuart has, from the first institution of this Company, been one of its hard-working and indefatigable Directors, and to those who can judge of the anxiety and work that this has entailed, I think I need urge no further reason for his re-election. I beg to move

"That the Right Hon. Lord Thurlow and Colonel Frederick G. Steuart be re-elected Directors of the Corporation."

Mr. COPLAND seconded the motion, which was carried.

Mr. COPLAND moved the re-appointment of Messrs. Cooper Bros. and Co., as auditors,

Mr. BLESSLEY seconded the motion, and it was also carried.

Mr. WEIR: Gentlemen, before we part I beg to propose a hearty vote of thanks to the Chairman for his conduct in the chair to-day, and to his colleagues as well, for the way in which they have managed this successful pioneer company and brought it to a profitable issue. If you would allow me I would supplement that by adding the names of the officials to those of the Directors. I beg to move that.

Mr. HART: I shall have very great pleasure in seconding that vote of thanks.

The proposition was adopted.

The CHAIRMAN: On behalf of myself and my colleagues, I beg to thank you, gentlemen, for your renewed expression of confidence, and to assure you that in the year to come we shall endeavour to serve you as well as we have in the past twelve months, and we hope that the result will be still more satisfactory, and that we shall be able to meet next year and divide the profits.

The meeting then closed.

The Telephone Company of Egypt (Limited).

The sixth ordinary annual meeting of this company was held at the Offices, 14, Austin Friars, E.C., on Tuesday, 12th inst., under the presidency of General Fraser, C.B., R.E.

The following is the report of the directors:—

After writing off a sum of £227. 8s. 7d. for depreciation, and providing for interest and expenses incurred in connection with the issue of debentures, the net profit for the year is £4,025. 10s. 5d.; adding to this amount the sum of £665. 2s. 6d. brought forward from 1887, the balance available for disposal is £4,690. 12s. 11d. Out of this the Directors recommend a dividend of 6 per cent. for the year, on the Preferred shares, free of income-tax, which will absorb £3,621. 6s. 0d., leaving £1,069. 14s. 11d. to be carried forward.

The re-arrangements for the management in Egypt, consequent on the death of the late manager, Mr. A. D. Evans, have proved satisfactory, and the Directors were glad to have been enabled to entrust that office temporarily to his son, Mr. W. N. Evans, who has since been confirmed in the appointment.

The loss of revenue during the year through the withdrawal of subscribers and other causes has been fully met by the continued growth of the exchanges, the total number of subscribers in Egypt on the 31st December being 980, against 917 the previous year.

The extension from Cairo to Hélouan, mentioned in last report, has been established with satisfactory results.

Efforts have been made to open a small exchange at Port Said, and it is hoped that during the current year the work may be carried out; at present, however, the support promised is not sufficient to warrant the commencement of the undertaking.

The apparent increase of the working expenses is due to the fact that the whole of the wages and salaries of the permanent staff have during the past year been charged against revenue, the Directors being anxious, so far as possible, not to increase the expenditure on capital account.

In accordance with the notice in the last report the sanction of the shareholders was obtained to an issue of debentures not to exceed, in all, the sum of £20,000. Of this amount £5,000 were issued in Egypt, and the loan from the Oriental Company was paid off.

Under the Articles of Association General Fraser, C.B., R.E., the Chairman of the Company, retires from the direction, but, being eligible, offers himself for re-election.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
DURO METAL
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
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WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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Messrs. Price, Waterhouse and Co., the auditors of the Company, also retire, and offer themselves for re-election.

The SECRETARY (Mr. Alex. B. Chalmers) read the notice convening the meeting.

The CHAIRMAN said: I assume, gentlemen, that the report of your Directors and the accounts presented therewith may be taken as read. I may, on the whole, congratulate the shareholders on the continued prosperity of their undertaking in Egypt, and I am glad to be able to say that the management in that country has suffered no deterioration by the confidence we have placed in the late manager's son, whose assiduity and capacity bids fair to come up to those attributes of his late father. We have also been able to utilise the services of a daughter of the late manager, whose clerical ability and knowledge of accounts are considerable. Your Directors have, therefore, been able, with advantage to the Company, to place their late manager's family beyond pecuniary difficulty. It may, perhaps, be said that in carrying forward so large a sum as £1,069. 14s. 11d. we are erring on the side of caution; but it must be remembered that we have no working capital, and that we should have money in hand to start any fresh extension. We have, moreover, so far made no provision for the redemption of debentures, and a good balance in hand will give confidence to any further issue of these bonds which may be necessary to enable us to carry out any important extension. The continued prosperity of your business depends to a great extent on the continued prosperity of the country which is the scene of your useful labours, and we feel that we should always be prepared to enter upon any new field which may be open to us. We may hope for an increase of business, but we have also to face a constant desire to reduce the rates of subscription. From our commanding position we can do the work very thoroughly and efficiently, and the more thoroughly we do it the less fear is there of competition, and if by a considerable increase in our business the cost of our administration is spread over a larger area, we should no doubt be able to give our subscribers some share of the benefit to be derived from a smaller percentage of working expenses. It does not appear to me that we can be more economical in actual working than we are at present. Our staff in Egypt is thoroughly efficient, and your thanks are fairly due to Mr. W. N. Evans and his staff. Considering that gentleman's youth, we thought it expedient to give him the aid—voluntarily offered—of three gentlemen of experience and influence, who offered their assistance as a consultative committee in Egypt. These gentlemen were—Mr. T. C. Chapman (the P. and O. Company's agent at Alexandria), Mr. George Goussio, banker in Egypt, and Mr. Smith, the superintendent in Egypt of the Eastern Telegraph Company. In such esteem was the late manager held in the country that they came forward to help the son gratuitously, but your Board, having derived benefit from their generous assistance, has thought it fit to offer each a small honorarium, by means of which they should in no way be out of pocket. We have carried no very large sum to depreciation, because we think that as the working must be kept in perfect order, the renewals and maintenance charged against revenue fully compensate for any temporary deterioration of wires, poles, and instruments. There is nothing further which it occurs to me to say, but I shall be glad to answer any questions on the subject of the business before us. No question being asked, the Chairman continued, I beg to move—

"*That the report and accounts for the year ended 31st December, 1888, be and are hereby approved and adopted, and that a dividend be paid of 6 per cent. on the Preferred shares, free of income-tax.*"

Mr. HENRY GREWING: I beg to second that.

The motion was carried unanimously.

Mr. THOMAS LLOYD: I beg to propose—

"*That General Fraser, C.B., R.E., be and he is hereby re-elected a Director of the Company.*"

Mr. ADDISON seconded the motion, which was carried unanimously.

The re-election of the auditors, Messrs. Price, Waterhouse and Co., having been proposed and carried,

Mr. ADDISON moved—

"*That a vote of thanks be accorded to the staff in Egypt for the able manner in which they have conducted the business.*"

This was seconded by Mr. LLOYD and unanimously agreed to.

On the motion of Mr. ADDISON, a vote of thanks was then passed to the Chairman, and the meeting terminated.

The Direct Spanish Telegraph Company (Limited).

Report of the Directors to be presented at the half-yearly general meeting, to be held at Winchester House, Old Broad-street, London, E.C., on Monday, the 25th instant, at 12 o'clock:—

1. The accounts for the half-year ended 31st December, 1888, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,720. 4s. 10d.

2. The traffic receipts show a decrease of £305. 4s. 11d. as compared with the corresponding half-year of 1887. The falling off in the receipts for last half-year is attributable to the slackness of the fruit trade, owing to the inferior crop of last year in Spain.

3. The working expenses are £95. 12s. 11d. less than in the corresponding period of last year.

4. The Company's cables and the land lines in connection with them have continued in good working order throughout the half-year. Unfortunately since the expiration of the half-year for which the accounts are now submitted an interruption of the Bilbao cable has taken place; the cable was, however, speedily restored, and has worked well since. The Directors propose that the cost of these repairs (£2,966. 10s. 7d.) shall be charged partly to reserve fund and partly to revenue.

5. After putting £2,500 of the balance of profit and loss to the reserve fund, which amounts to £13,660, there remains an available balance of £3,220. 4s. 10d. Out of this amount the Directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the Preference shares, and a dividend at the rate of 4 per cent. per annum (free of income-tax) on the Ordinary shares, making with the previous distribution 4½ per cent. for the year 1888, against 4 per cent. in the year 1887. This will admit of a sum of £723. 5s. 3d. being brought forward to next account towards the payment of the portion of the cost of the repairs of the Bilbao cable charged to revenue. The dividend warrants will be issued on 1st April, 1889.

6. Sir James Anderson and Mr. Denison Pender are the Directors retiring by rotation, and, being eligible, offer themselves for re-election.

7. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The directors of this company on Wednesday declared an interim dividend of 3s. per share, being at the rate of 6 per cent. per annum, free of income tax, for the quarter ended December 31st, 1888, and payable on the 25th inst. The books of the company will be closed from the 18th to 23rd inst., both days inclusive. The traffic receipts for the week ended March 8th, 1889, amounted to £5,575.

DIRECT SPANISH TELEGRAPH COMPANY.—After transferring £2,500 to the reserve fund, the directors of this company, in their half-yearly report, recommend a balance dividend at the rate of 4 per cent. per annum, making a total distribution for the year 1888 of 4½ per cent.

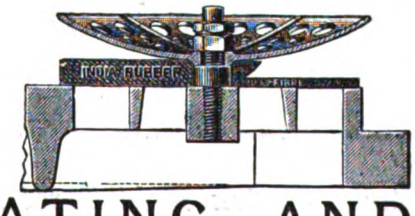
ORIENTAL TELEPHONE COMPANY.—The directors of this company on Wednesday resolved, subject to final audit of the accounts, to recommend to the shareholders a dividend of 3 per cent., free of income tax, on the paid up capital of the company (other than the vendors' shares), for the year ended December 31st last, placing £2,500 to reserve and writing off the whole of the balance of the preliminary expenses, amounting to £3,000, leaving an amount of some £500 to be carried forward.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 8th, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,401.

We learn that Messrs. Mix and Genest, the well-known Electricians, of Berlin, have sold their establishment to a group of banking firms with the view of transforming the same into a joint stock company.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL." "12, John-street, Sunderland, 26th Sept., 1885.

For further Testimony and Prices, apply to MOSSES & MITCHELL, 68-71, Chiswell Street, London.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Mar. 13, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Mar. 13, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	15,0	Anglo-American	48½ 49½	3 5 8	Jan., Apr., July, Oct.	49	...
2,614,820	Stock	30/0	Do. Preferred	82½ 83½	3 17 10	,, ,,	83¼	82
2,614,820	Stock	15/0	Do. Deferred	16½ 17	...	February	16⅞	...
130,000	£10	3/0	Brazilian Submarine	13⅝ 13⅞	5 1 0	Mar., June, Oct., Dec.	13 13/16	13⅛
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	102¼	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	107	...
16,000	10	9/0	Cuba Submarine	14 14½	6 4 2	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3⅜ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	9¼	...
60,710	20	3/6	Direct United States	9½ 10½	3 19 0	Jan., Apr., July, Oct.	10⅛	10
380,000	10	2/6	Eastern	12⅞ 13⅛	4 11 5	,, ,,	13 3/16	13
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	15⅜	15
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	108	106¾
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	106½	...
250,000	10	2/6	Eastern Extension	12⅞ 13⅛	4 19 1	Jan., Apr., July, Oct.	13⅛	12 15/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	103¼	102¾
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	102⅛	...
179,177	10	1/3	Globe Telegraph and Trust	6⅞ 7⅛	5 1 9	Jan., Apr., July, Oct.	7⅛	6 15/16
178,992	10	3/0	Do. 6 per Cent. Preference	14¼ 14½	4 2 9	,, ,,	14 7/16	14⅛
150,000	10	5/0	Great Northern	15 15½	4 16 9	Jan., July, and April	15½	15¼
17,000	25	12/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	6¾ 7¼	5 10 6	April and October	7⅛	...
15,609	10	3/0 1887	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	100 103	4 17 1	March & September	...	...
30,000	10	6/0	West Coast of America	9¾ 10¼	4 17 7	January and July	10 1/16	9⅞
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜ 1⅝	...	...	1½	1⅜
34,563	10	12/0*	Do. 1st Preference 6%	11 11½	...	April and October	...	...
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	13¾ 14¼	...	March & September	13 15/16	13½
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	5%	Consolidated Telephone and Maintenance	⅜ ⅞	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	⅜ ½	2 14 11	...	7/16	...
80,000	5	5/0	United	14⅞ 15⅛	4 19 2	June and December	15⅛	14⅞
55,000	5	3/0	United River Plate	5⅜ 5⅝	...	January and July	5⅝	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3½ 3¾	...	...	3⅜	...
23,692	5	2/0	Do. (fully paid)	4½ 4¾	...	February & August	4⅜	4¼
79,934	5	nil.	Swan United (£3. 10s. paid)	2¾ 3	...	...	2 11/16	2⅝
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	40 42	5 14 3	March and July	42	40½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works	17½ 18½	5 8 1	February & August	18⅛	17¾

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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No. 566.—Vol. XXII. FRIDAY, MARCH 22, 1889. Price Fourpence.

NOTES.

An important step has been taken by the Board of Trade in reference to electric lighting in the metropolis by the appointment of Major Marindin to hold an inquiry into the various schemes for which Provisional Orders and Licenses have been sought. The inquiry is to commence at 10:30 a.m. on Wednesday, April 3rd, at 8, Richmond-terrace, Whitehall. Some further reference to the matter will be found in another part of this issue.

The important Paper of Prof. J. J. Thomson "On the Resistance of Electrolytes"—an abstract of which we print in this issue—will be read with interest, not merely for its own sake but also because it affords the first illustration of the employment of one of the Hertz phenomena as an instrument of research—and a very powerful instrument it is seen to be. The Paper, which was received by the Royal Society on January 9, commences with a statement of the "theory of screening," and by a coincidence we published two days later the independent investigations of Dr. Fleming upon the same subject. The results arrived at—which it is needless to say are identical in each case—may be briefly expressed by saying that if a sheet of any conducting material be interposed between a primary and a secondary circuit of which the former conveys an alternating current (including, of course, an oscillatory discharge) the extent to which the secondary circuit is shielded from the induction of the primary depends directly upon the thickness and specific conductivity of the screen, and inversely upon the frequency of the primary current. Prof. Thomson, therefore, took two horizontal circuits whose time constants were equal, and in one of which very rapid electrical oscillations were established, and between them he interposed a horizontal tray in which various electrolytes could be placed. The particular thicknesses of the liquid strata which effectually screened off the electric radiations are proportional to their specific resistances, so that the method affords a means of directly comparing the relative resistance of different electrolytes with currents of very different frequencies. It is evident that the great advantage of the method consists in the absence of electrodes, the currents in the electrolyte being of the nature of Foucault currents. Prof. J. J. Thomson concludes from the experiments that "the relative resistance of electrolytes is the same when the current is reversed a hundred million times a second as for steady currents." Further interesting experiments are detailed in the Paper.

At the Royal Society yesterday (Thursday) afternoon Mr. Shelford Bidwell communicated an experiment which, to all appearance, affords evidence of a direct action of light upon magnetised iron. We print on another page an abstract of the Paper, from which it will be seen that the success of the experiment is largely due to the use of iron specially prepared, so as to be in a condition of magnetic instability. When a beam of light is thrown upon such a piece of iron its magnetic condition undergoes an almost instantaneous change. The experiment is one of great beauty and suggestiveness. Mr. Bidwell is now engaged in following up this line of research, so as to ascertain if possible the exact nature of the effect.

The very adverse report of Prof. Forbes upon the durability of the lead-covered cables in Berlin naturally created something like a scare amongst the users of this class of wire in this country. According to the information furnished to Prof. Forbes the life of a cable insulated with a bituminous compound and lapped with lead—such as is supplied by Messrs. Siemens and Halske—when buried in the soil cannot be taken to exceed three years. If this be absolutely true it is most desirable that the fact should be fully understood. The statement is the more surprising since the durability of lead when buried in the soil has hitherto been an article in the creed of most electricians. Mr. Preece, speaking last week in the discussion on Prof. Forbes' Paper, mentioned the well-known case of the pneumatic tube laid in 1854, he also exhibited a piece of lead-covered cable still in perfect condition which had been buried ten years earlier. But valuable and reassuring as this evidence undoubtedly is, we should like to ask whether any instance of failure similar to that described by Prof. Forbes has ever come under the notice either of Mr. Preece or of any one else; if so it would be of great value to know the exact conditions under which the deteriorations occurred.

In respect of the alleged failure of the Siemens concentric cables at Berlin, Mr. Alexander Siemens was able to make a statement of a reassuring tendency. It appears that these cables gave no trouble until towards the end of last year, when the leads of the three central stations were all connected in parallel. It is true that prior to this an occasional fault had occurred—almost invariably due to mechanical injury—but the daily insulation tests had sufficed for its discovery and localisation before it had developed to anything like serious

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proportions. Since, however, the leads were joined together it has no longer been found possible to take insulation tests, and when the cable has suffered damage the fact has remained undiscovered until something serious has taken place. This state of affairs has given rise to considerable friction between the Allgemeine Electricitats Gesellschaft and Messrs. Siemens and Halske, and as Mr. A. Siemens explained, Prof. Forbes happened to visit the installation at a time when the friction was at its height, and, doubtless, he heard the worst that could be said for the cables. We do not, however, believe that the testing of the cables for insulation under the above conditions is absolutely beyond the resources of electrical science, although, doubtless, the localisation of a fault will be more troublesome than before. We have several times called attention to the excellent results obtained at Brooklyn with cable coated with lead to which a small proportion of tin is added. We do not understand why this alloy has not been brought into more extensive use in this country.

The project of holding a "convention" of telephonic engineers—as suggested by our contemporary *The Telephone*—is one to which we are prepared to give the fullest approval. From a purely technical standpoint it is impossible to doubt that much good would follow from the mutual exchange of advice and experience amongst telephone engineers. At the same time we are well aware that this view does not find favour amongst the directors of the *haute politique* of telephony. In its various discussions on matters telephonic the *quondam* Society of Telegraph-Engineers listened in vain for the voices of the engineers and electricians of the telephone companies. More than this, we happen to know that when Papers have been offered to the Society by the *employés* of provincial companies, and with the consent of their directors, the parent company has stepped in and secured their withdrawal. Such having been the policy hitherto adopted, it will afford us the greater pleasure to learn that the United Telephone Company has now been converted to more enlightened views. If, however, the consent of the parent company be not obtained, we very much doubt whether the convention could be successfully held.

We understand that the negotiations for the amalgamation of the Telephone companies are now so far advanced that a definite announcement may be expected at a comparatively early date. The present scheme includes only the United, the National, and the Lancashire and Cheshire Companies; but if these three giants can arrive at an agreement they will probably find little difficulty in dealing with their weaker brethren. We may add that in anticipation of eventual combination the National Telephone Company for some time past has laid out and constructed its trunk wires with a view to their ultimate junction with the metropolis. Meanwhile the London-Birmingham wire is making but slow progress, and we note also that in a recent number of our contemporary, *The Telephone*, the wisdom of employing so small a gauge as 12½ (hard-drawn copper) is severely criticised. In any case, it is to be hoped that this line has been considered merely as the first link in the chain of through communication to the Midlands and the North. If it has been designed merely with a view of speaking to Birmingham and no further, we think a serious mistake has been made.

The Paris Municipality, whilst seeking to foster the employment of central station plant during the hours of daylight, has been led into a most extraordinary blunder. According to the scale of charges just promulgated, the supply companies are instructed to charge so much *per carcel-heure* (!) for light, and so much per horse-power hour for motive power. It is quite unnecessary to enlarge upon the sheer absurdity of a photometric tariff; but as if the decree was not already sufficiently ridiculous, the prices have been arbitrarily fixed at 0·45fr. per horse-power hour, and 0·045fr. per carcel-heure. Now, as our contemporary, the *Revue Industrielle*, justly observes, at this rate it would, as a rule, be cheaper to obtain light by the use of a motor coupled to a dynamo rather than to utilise the current directly in the lamp. This edict is in fact a fine example of municipal electro-technics.

M. Popp is, of course, well known as the advocate and the successful introducer of the system of distributing energy by means of compressed air, and, as we have from time to time made note, his station at St. Fargeau already supplies power for a considerable amount of isolated electric lighting plant in the centre of Paris. We understand that for the purpose of lighting the important district which has been allotted to him some 9,000 horse-power will be added to the existing engines at St. Fargeau. A special air conduit 30 centimetres in diameter and 8 kilometres in length will be laid down, and from this a number of sub-distributing stations will be fed. Our Paris correspondent mentioned last week that accumulators were to be employed, but we note that *L'Électricité* credits M. Popp with intentions of a much more remarkable character. According to this authority each sub-station is to be equipped with a compressed air engine driving a continuous-current dynamo, which, by means of a special commutator, supplies alternating currents to a primary transformer, which is to feed secondary transformers at the subscribers' houses. Well may our contemporary exclaim, "*Que de transformations!*"

We are glad to learn that the number and character of the applications already received by the Birmingham Electrical Exhibition Committee are such as to assure the complete success of the undertaking as a representative collection of the appliances of modern electrical engineering. One feature of the Exhibition will be that, outside the dynamo department, the whole of the motive power will be supplied by electro-motors, and notwithstanding the large number of entries in this class the committee have already found it necessary to obtain additional machines, in order to furnish the power applied for. In respect of electro-motors, the show will certainly be unique, and the committee are also anxious that it should include as many different types as possible. An equally important feature will be the display of central station outfit, and it is hoped that an opportunity will

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be afforded of examining and comparing every system of electrical distribution which is to be found in operation.

We understand that the Metropolitan Electric Supply Company has taken over the small central station in Berners-street, Oxford-street, which was started about a year ago as a private speculation by Messrs. Pritchett and Co. The plant at present in use consists of two 80 horse-power Mordey alternators, which furnishes current to Mordey transformers, supplying about 1,500 16 candle-power lamps. This station has worked with perfect success from the very first. We believe, however, that in the further extensions which are contemplated by the Metropolitan Company plant of the Lowrie-Parker type will be installed.

From the annual report of the London Chamber of Commerce for the year 1888, which has just appeared, we gather that, whilst the thirty-five Trade Sections and General Committees of the Chamber held between them 153 meetings, or an average of 4·4 apiece, the Electrical Section, in the first three months of its existence, held no less than eleven meetings, or an annual rate exactly four times greater than the average. The report mentions incidentally that the Section is now also one of the strongest numerically in connection with the Chamber. The work hitherto accomplished is referred to in the following terms:—

"The first practical step taken by the Section consisted in drawing up a series of recommendations defining the relations of supply companies with local authorities in regard to licenses or provisional orders, and amongst the subjects with which it was considered desirable to deal were the following:—Uniform method of charge by undertakers; infringement of patents; increase of Board of Trade unit; supply companies control of wiring houses in their districts; overhead wire regulations; the position of the trade in relation to the Electric Lighting Act; Board of Trade regulations and accounts (in regard to which some progress was made before the end of the year); agreement between the electric lighting firms and insurance companies, and between the firms themselves, to determine the fundamental requirements in all cases and to avoid favouring; Board of Trade regulations as to testing mains and meters; proper inspection of work on electric lighting installation in connection with fire risks; Tramway Act; recognition of electrical standards; reports on exports, markets, customs duties, railway rates and share quotations; fire insurance rules; standard specifications; and standard types of apparatus. Some of the foregoing matters have already engaged the attention of the Section, and a satisfactory result has been recently attained in the adoption by the Board of Trade of a unit of 10,000 watt-hours, instead of 1,000 watt-hours as heretofore—a change which the Section has strongly advocated."

We may add that the March meeting of the Committee of the Section has not yet been held, owing to unavoidable causes. We anticipate that the Committee will shortly call a meeting of the whole Section to report progress.

In reference to the process of tanning leather by the aid of electricity, of which we have spoken lately, a contemporary journal—*The Shoe and Leather Reporter*—is delivered of the following sapient pronouncement:—

"Notwithstanding the signal failure of electricity in refining sugar, we still hesitate to pronounce definitely against the efficacy of this new element in forcing the tannin in the gelatine of the hide."

To which we would in like manner rejoin that, notwithstanding its signal failure to comprehend the exact nature of the relations between electricity and sugar, we are free to admit that our contemporary is a useful and respectable publication in its own particular walk of life.

Copper has been sold this week as low as 35, and was quoted yesterday at 40 to 42.

"The Electrician's Paper."—An electrical journal, called *The Electrician's Paper*, is now being published at St. Petersburg.

Teddington.—The new church at Teddington is to be lit by electricity, the current being supplied from Earl Russell's house close by.

Exeter.—It will be seen by our advertisement columns that the directors of the New Theatre Royal, Exeter, invite estimates for the electric lighting of this theatre.

Sale of the Elieson Plant.—The sale of the patents and plant of the Elieson Electric Company will take place on Wednesday, April 17th, at Plashet Hall Works, Stratford.

Chelsea Electricity Supply Company.—The work of drawing in the cables belonging to the Chelsea Electricity Supply Company has now begun, and the light will be supplied to the residents who have had their houses wired in a few weeks time.

Chelsea Vestry.—At a meeting of this Vestry last week, the Electric Lighting Committee reported recommending that the Vestry assent to a proposed extension of the area of supply by the Chelsea Electric Supply Company. The report was adopted.

Reduction of Tariff to South America.—The Brazilian Submarine Telegraph Company announces that, on and after the 1st April, a reduction of rates to South America will be made, of which full particulars will be found in our advertisement pages of last week's issue.

Electric Traction at Brussels.—The experiments with electrically propelled tramcars which took place during the past year at Brussels, and which yielded somewhat unsatisfactory results, will be renewed shortly in the Rue de la Loi. This part of the line includes a very steep incline, and if the present trials are satisfactory it is probable that the system of electric traction will be adopted on all the lines.

The General Electric Company.—We have received from the General Electric Company (G. Binswanger and Co.) a copy of the seventh edition of their illustrated catalogue of electric bells. This catalogues has been considerably enlarged, and now contains some 55 pages and over 260 illustrations. Full descriptions with prices are given of a large variety of batteries, bells, pushes, and almost every requisite of domestic electricity.

Specific Resistance and Temperature Coefficient of High Resistance Liquids.—Those of our readers who have occasion to make determinations of the above will find a handy form of apparatus described in the *Centralblatt*, Vol. XI., No. 1, by Dr. J. Otten, who also points out a source of error due to the slow contraction of the glass tube form of containing vessel which occurs for some hours after working.

Ohm Memorial Fund.—The contributions hitherto paid or promised in this country towards the intended statue of G. S. Ohm amounts to £95s. 14s. 6d., from 94 subscribers. It is proposed to close the subscription list at the end of the present month, and we are desired by the committee to ask intending subscribers to send their contributions as early as convenient to the Treasurer, Dr. Hugo Müller, F.R.S., 13, Park-square, N.W.

Electrotherapeutics.—A series of experiments on the mode of diffusion of voltaic currents in the human body has led M. L. Danion to the following conclusions, which were published in a recent number of the *Comptes Rendus*. With the exception

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of the skin and the bones, the various constituents of the human frame have practically the same resistance. The resistance of the bones is 2½ times greater than that of the hypodermic tissues.

Law Courts Branch Bank of England.—We understand that the electric light installation at this bank is now completed and running well. A total of 220 lamps have been fixed throughout the bank and agent's house, the current for which is obtained from a 12-unit Elwell-Parker dynamo driven by a Crossley gas engine. The battery was manufactured by Elwell-Parker (Limited), to the specification of Messrs. Drake and Gorham, who carried out the installation.

Long Distance Telephony.—In the *Electrotechnische Rundschau* for March will be found an article by Dr. Wietlisbach, of Berne, on the above subject. The article is too long to reproduce in full, but the author comes to the following agnostic conclusions:—"There is, up to the present day, no formula known which will give the limiting distance for telephone work with any approach to accuracy; no reliance can be placed on data obtained from any experiments yet made; the limit for overhead copper lines has never yet been reached."

Telephone Call Rooms in London.—In addition to the twenty-four call rooms at present available in London, the United Telephone Company will this month open additional rooms at Richmond, Willesden Green, Kew Bridge, Forest Gate, Shepherd's Bush, Norwood, and Lewisham, and preparations are being made for stations at Streatham Hill, Brixton (second), Sydenham, Hampstead, and Leytonstone. Subscribers make use of these call rooms free, and non-subscribers at a charge of sixpence.

The Lighting of the House of Commons.—It appears that the addition of the electric light to the arrangements of the House of Commons has increased rather than decreased the expenses for gas. Last year the gas bill was £3,300, whilst the cost of the supply for the coming year is estimated at £4,000. This is in addition to an increase in the expenditure on electricity of £40. The supply of oil lamps in the Houses of Parliament still maintains its immense proportions. This year as last not less than £2,000 is paid for oil for the lamps.

Medical Electricity.—The Société Médicale de Bruxelles has offered a prize of 2,000fr. for the three best Papers upon the following subjects:—1st. The measurement of the electric currents in the animal tissues. 2nd. The measurement in ohms of the resistance offered by liquids and tissues in living organisms to feeble currents. 3rd. A review up to date of the works on, and researches into, the theory of electric endosmose and its application to the phenomena of secretion in living organisms. The papers must be sent to Dr. Stienon, Rue Horn, Brussels, before January 1st, 1890.

St. Alban's.—At the last meeting of the St. Alban's City Council the following report was read: Your committee who were appointed to inquire as to the probable cost of lighting the city by electricity, beg to report that they have made inquiry as to the probable cost of establishing and maintaining electric lighting works in this city, and are of opinion that no reliable estimate can be obtained except at considerable cost, and under these circumstances they recommend that they be discharged from further prosecuting the inquiry entrusted to them. It was agreed to dissolve the committee.

Dorchester.—An application was recently made to the Dorchester Gas Company by the Town Council for a reduction in the charge for the public lighting. The directors, in reply, reminded the Council that the terms of the contract of 1887 were approved of by the Corporation, and as the cost of producing gas is the same now as it was then, they could not see their way to making any alteration in the price. After some discussion, it was resolved to apply to an electric light company to furnish an estimate for the supply of the light. It was also resolved to inform the Gas Company that the Council did not consider the letter satisfactory.

The Post Office Telegraph Service.—An estimate of the additional amount required in the year ending March 31, 1890, to defray the salaries and working expenses of the Post Office Telegraph Service, in consequence of new arrangements for working the submarine telegraph cables between England and Belgium, France, Germany, and Holland, was issued a few days since. The gross total of the estimate is placed at £60,050, against which there is to be set off the sum of £10,150 constituted by receipts from the telegraph administrations of the aforesaid Continental countries for one-half the cost of maintaining the cables. The net total is, therefore, £49,900.

Electric Meter Competition in Paris.—The decree of the Prefet de la Seine authorising the long-talked of meter competition has just been published, together with the programme. The meters and sketches must be left under seal between the 15th and 25th May at the Hotel de Ville, Paris, at the office of the Sous-directeur des Travaux. The programme of this competition will be found in our issue of January 18th, p. 299. A sum of 20,000fr. will be distributed among the successful competitors, viz., 10,000fr. to the inventor who produces a meter giving complete satisfaction, five premiums of 2,000fr. to the designers of the five next best meters, half the above sums being awarded if the meter can only be used with one kind of current.

Chester.—Last Friday week a meeting of gentlemen interested in the formation of a central station for the supply of electricity in Chester was held at the Town Hall to confer as to the expediency of introducing the electric light into the city. Mr. T. V. Hughes, an electrical engineer of the city, said he had canvassed the neighbourhood, and had received promises for about 300 lights from several of the more prominent citizens, and this being so, they had prepared an estimate on that basis. Mr. Manville subsequently addressed the meeting, entering into many details in connection with the proposals. A desultory discussion followed, and in the end Messrs. Hughes and Manville were requested to prepare a circular giving information as to cost, &c., of a central supply station.

The Cable to Morocco.—The following telegram has appeared in one of the daily papers:—"For some time past the Madrid Press has been publishing reports from Morocco to the effect that the cordial relations hitherto existing between the Sultan and the British Legation at Tangier were disturbed, because the Moorish authorities are said to oppose the repair and re-establishment of the British cable between Tangier and Gibraltar which the Sultan had authorised only a year ago, when it was first laid down. The Moors are also stated to be watching the coast, in order to resist the laying of the shore end of the cable near Tangier. The Spanish papers say that the Sultan is encouraged in his attitude towards English interests by several foreign representatives at Tangier. Finally, it is announced to-day that the British Legation has sent to the Sultan at Fez a note demanding a decision about the cable in ten days, and in this step the British Legation is backed by the presence of the fleet at Tangier.

Telephonic Communication in Paris.—The Municipal Council discussed at a recent meeting various proposals for improving telephone communication in Paris. The concession of the present company lapses on September 8th, and whether it is renewed or not the rates will be lowered and better communication secured. At present the subscription in Paris is about £24 a year. The complaints about the service in Paris have at length had some effect, the company having spent over £8,000 last month on improvements, on the chance of obtaining the renewal of its concession. Among the most ingenious proposals is that of M. Leon Donnat, a municipal councillor and leading economist, who would give the lease of the telephone system to the subscribers themselves, incorporated as a co-operative society. The rate would be reduced to £16 a year at the utmost, and in addition to this subscribers would benefit as part proprietors, while the city would probably gain by the increased exchanges.

Chelmsford.—A special meeting of the Chelmsford Town Council was held on Wednesday evening last week to consider the future lighting of the borough. Four tenders for the lighting of the town had been sent in to the lighting committee. Crompton and Co. (Limited) offered to supply 20 arc lamps, 72 incandescent lamps, and 38 oil lamps, for five years at the rate of £700 per annum. The committee recommended the council to accept Messrs. Crompton and Co.'s tender, provided that the

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term for which the firm retained the right of private lighting be reduced to five years from the expiration of the contract, and subject to the details of the contract being approved by the lighting committee. Several members having shares in the Gas Company wishing to speak, the Town Clerk said he had consulted counsel on the subject, who was of opinion that any shareholders in a gas company might lawfully vote either for or against the adoption of the report and might take part in the discussion, as they had not a pecuniary interest in the matter within the Municipal Corporations' Act, 1882. After a long discussion an amendment in favour of adjournment was put and carried by a majority of one vote. It was subsequently decided to call a meeting of burgesses to consider the question, and the committee was requested to inspect the proposed position of each lamp and to report again.

The Submarine Company's Cable.—The *Central News* states that the representatives of the French and Belgian Telegraphs Department who were deputed by their respective Governments to discuss with the English officials the terms upon which the submarine cables between England and those countries should be taken over, have arrived at an agreement as to the price which shall be offered for the cables and plant. This was promptly communicated to the British Treasury, where the agreement arrived at was definitely approved, and an offer was immediately afterwards made to the Submarine Telegraph Company on behalf of the countries interested. The price which the three countries have agreed to pay is not so large as the directors of the Submarine Telegraph Company expected, but, on the other hand, it is far from being a confiscation price, which many of the shareholders anticipated. The amount will be announced in Parliament within a few days, immediately after the French and Belgian Governments have ratified the decision arrived at by their representatives. There is now not the slightest doubt that this will be done, and that the General Post Office will be in a position to take over the working of the submarine cables on the 1st of April. The officials of the English Post Office are to be congratulated upon the skill which they have displayed in bringing this most difficult business to a successful issue.

Influence of State of Aggregation on Electrical Resistance.—It was pointed out long ago by Clausius that according to the results of Arndtsen's researches on the electrical resistance of metals, the resistance of a simple metal in the solid state is directly proportional to the absolute temperature. This was subsequently confirmed by Werner Siemens, with the limitation that it does not hold good for temperatures near the melting point of the metal. Grunmach, in a recent number of *Wiedemann's Annalen*, describes some experiments from which it appears that the variation in the resistance of pure mercury does not obey this law even at temperatures much below the melting point. He finds that the temperature coefficient between 40 and 90 diminishes steadily with the temperature, as shown by the accompanying table :—

Temperature.	Temperature coefficient.
−40° to −50°	0·00226
−50° ,, −60°	0·00134
−60° ,, −70°	0·00111
−70° ,, −80°	0·00078
−80° ,, −90°	0·00037

For fluid mercury he obtains the temperature coefficient 0·00086, which is in fair agreement with Werner Siemens's value 0·00095, and the value 0·000882 obtained by Mascart, Neville and Benoît. According to Grunmach, the resistance during liquefaction only increases to about 1·5 times its original value, a much smaller increase than Cailletet and Bouty and C. L. Weber have given as the result of their investigations.

Electric Lighthouses.—Last week's Friday evening discourse at the Royal Institution was given by Sir James N. Douglas, on "Beacon Lights and Fog Signals." After tracing the history of the subject from the earliest times, the lecturer said that it was in 1858 the Trinity House first consulted Faraday on the use of the magneto-electric light. Experiments were made at the Nore, and he reported that it not only fulfilled all the requirements of an illuminant but gave prospects of development the limits of which it was hardly possible to foresee. These prophetic words had been verified. He (Sir James) had devised fluted carbons, with which it was possible to obtain a light of 150,000,000 candle-power. This was 400 times greater than could be obtained from any flame illuminant. It was far too dazzling to be used at its full power in clear weather, while, like all other lights, it was practically useless in fogs. There were intermediate atmospheric states, however, in which it was of the highest value. We are gradually coming, said Sir James, to recognise that, while electricity has undoubted superiority for salient headlands and rocks at a distance from the coast, oil or gas lights are more suited for narrow navigations. With the increase of commerce and the rapid additions to lighthouses plain fixed lights are of little use. There are the alternatives of coloured lights and intermittent lights, and it is found an occulting light has advantages over a revolving. Sir W. Thomson had suggested flashings on the dot and dash system. This might be by long and short duration lights, or red and white. For fog signals the detonation of packets of dynamite by electric currents at intervals, and automatically controlled, is the latest development. But fog, unless uniform, is an impediment to sound as well as light. Fog penetration is the problem now awaiting solution.

Electrical Energy and Solar Radiation.—Prof. I. Thornton Osmond describes in the New York *Electrical Engineer* some experiments which he has recently carried out in order to test the possibility of converting solar radiation directly into electric energy. The following is the most interesting portion of the Paper :—

I constructed a polariser of a bundle of thin sheets of glass, set in a tube at an angle of 35deg. 25min. with the axis, giving a transmitted polarised beam about five centimetres in diameter. The tube was rotated by a belt from a wheel, a beam of sunlight being sent through it from a rude heliostat.

Three coils, from 18 to 63 cm. long, with different amounts of wire, and of different internal diameter, were fitted with soft iron tubular cores, with glass plates covering the ends. These were for holding vacuum, air, liquids, &c., to be traversed by the beam, whose plane of polarisation was being rotated by the polariser.

The following are some of my series of experiments :—

(*a*) Try whether an astatic needle, silk fibre suspension, placed axially in the rotating beam, is deflected ; the same, placed at right angles to the beam.

(*b*) Try, with astatic galvanometer, cutting the rotating beam variously by a loop of wire connected to galvanometer.

(*c*) Try several metres of wire lying in (along) the rotating beam, with the ends connected through the astatic galvanometer.

(*d*) Try several metres of wire, as in (*c*), but with ends attached to quadrant electrometer.

(*e*) As (*c*) and (*d*), but using an electro-dynamometer to see whether an alternating current is produced.

(*f*, *g*, and *h*) Try passing the rotating beam through the different coils, with air, water, carbon disulphide, &c., and using galvanometer, electrometer, and electro-dynamometer.

(*i*, *j*, and *k*) Try the above with arrangement for alternately admitting and cutting off the beam, either rotating or at rest.

l, *m*, *n*, and some other experiments, I will not at present describe.

(*q*, *r*, *s*) Try a coil of wire wound longitudinally on a bar of iron, 2·2 m. long, 2·5 cm. square, with astatic galvanometer, quadrant electrometer, and dynamometer.

(*t*, *u*, *v*) Try a coil of wire wound longitudinally on a wooden bar, 2·5 m. long and inserted in an iron water pipe, with astatic galvanometer, quadrant electrometer, and dynamometer.

These experiments were made in the second story of a five-story building (above basement) used for dwelling houses, dormitories and general college purposes. The apparatus, except the astatic galvanometer and quadrant electrometer, was very rude. The polariser is but partial, the means of rotation very inadequate, and the continual jarring of the building renders certainty as to small action of galvanometers, &c., impossible.

The result is (1), my work proves that there is no opto-magnetic or opto-electric action of sufficient magnitude to be certainly discoverable, with such apparatus and under such conditions as I used, by methods (*a*) to (*k*) inclusive. (2) It is far from disproving such action.

In fact, I believe in two or three of the experiments there was indication of slight electric action.

I hope to have within a year better conditions for work in the physics building (Pennsylvania State College), now under roof, to reconstruct some of my apparatus with greater efficiency, to add some, and with improved conditions and means to retry some of these experiments more decisively, and to continue the research by other experiments.

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NOTES ON ELECTRO-MAGNETIC INDUCTION.

BY DR. J. A. FLEMING, M.A.

(Continued from page 504.)

The theory must, however, be taken for no more than it is worth, viz., an attempt to construct a mechanical system which shall act in the manner in which we find electro-magnetic fields and circuits do act. The true mechanism *may* be very different; the one described has at least the utility that it shows a way in which the observed effects might be produced. The various dynamical elements in the supposed mechanism have their equivalents in the recognised electrical and electro-magnetic qualities. The angular velocity of the cells or vortices around their axes represents the intensity of the magnetic force, or the strength of the magnetic field. The angular momentum of the vortices represents the magnetic induction, and hence the mass of each cell, or the *density* of the medium, is the analogue of the magnetic permeability. This is greater in paramagnetic substances than in air or vacuum, and greatest of all in iron; in fact, so exceptional is it in iron that Maxwell supposed the particles of the iron themselves to take part in the vortex action. Hence, the energy of a magnetic field is greater if that field contain iron, and accordingly the presence of iron in a core immensely increases the vortex energy for a given vortex velocity, that is, it increases the inductance of the circuit. The energy associated with any revolving cell or vortex is proportional to the product of its velocity and momentum, or the product of the magnetic force, and the magnetic induction estimated in the same direction is a measure of the energy per unit of volume existing in that portion of the field. The "nnmber of lines of force" passing through any circuit is on this theory to be identified with the whole momentum of the molecular vortices linked with that circuit. If any circuit is traversed by lines of force or linked with lines of molecular vortices, and the cause creating this field is removed, say, by withdrawing the magnet or repressing the electric current creating it, the vortices give up their energy gradually to this secondary circuit, and it appears there as energy of motion of the electric particles or as electric current. When one system of bodies in motion sets another set in motion by mutual action and reaction, and there is no loss of energy by anything like friction or imperfect elasticity, then the momentum gained by one must be equal to that lost by the other, and the rate of gain of momentum of the one system is at any instant equal to the rate of loss of momentum by the other. Hence, if the vortices lose momentum their rate of loss of momentum—that is, the rate of withdrawal of lines of induction from the circuit must be equal to the rate of gain of momentum of, or to the force acting on, the electric particles which are absorbing the momentum. Hence we see that the impressed electromotive force in the circuit must be equal to the rate of withdrawal of lines of induction, and the theory conducts us to Faraday's law of induction as a necessary dynamical consequence of our fundamental assumption. Maxwell has extended the theory of molecular vortices to the explanation of electrostatic phenomena, with which we are not, however, here directly concerned. We have seen that the theory is capable of affording an explanation on mechanical principles of self-induction, mutual induction, and the law of electro-magnetic induction. In order to complete the theory as far as regards the phenomena of magnetism, it is necessary to suppose that the particles of magnetisable metals, such as iron, are set in rotation by the molecular vortices which traverse them, and that an increase of speed of these vortices does not increase proportionally the rotation of the iron molecules. These last behave like wheels slung loosely on a shaft between which shaft and the wheel there is friction decreasing as the speed of rotation of the shaft increases. If, then, the wheel experiences a constant frictional resistance from external causes, indefinite increase of speed of the shaft would accelerate the wheel's rotational velocity up to a certain point, and the wheel would then cease to rotate. This supposition would enable us to make our theory agree with the fact that increase of magnetic force does not increase indefinitely the magnetic induction through iron, but brings it up to a point at which, approximately speaking, the induction remains stationary. To sum up, we may say that the hypothesis of molecular vortices is an endeavour to imagine a mechanism capable of accounting for electro-magnetic induction on dynamical principles, and on the assumption that the energy of a magnetic field is energy stored up in a medium in virtue of a particular kind of rotation of its parts.

This medium consists of portions capable of elastic displacement when we consider parts of it lying in dielectrics or capable of progressive movement when in conductors, and these portions constitute what we call electricity. Other portions are capable of rotation round closed axes of rotation, and these constitute what we call "lines of force." The medium possesses, therefore, an elastic resilience, and the reciprocal of this quality, or its freedom of yielding to electromotive force, is recognised as the *specific inductive capacity*. The medium possesses also density, and we call this its magnetic permeability, or magnetic inductance. The mass of unit of length of the vortices is equal for all vortices, whether in vacuum, air, or non-magnetic bodies, but in iron the vortices are *loaded* by the adhesion to them of the molecules of the metal, and the density is increased, and hence the permeability; but for very great angular velocities—that is for great magnetic forces—the adhesion of the molecules and vortices must be supposed to cease, and the permeability approximates to unity. The magnetic force at any point in a field is the angular velocity of the vortex motion at that point, and the magnetic induction is the angular momentum. Magnetic attraction and repulsion is due to the tension set up along a vortex line by the polar contraction and equatorial expansion of the vortex cells. At places where there is magnetic polarity or free magnetism there is a discontinuity in the angular velocity of the vortices within and without the iron. Self-induction is the result of the *inertia* of the molecular vortices, whereby motion set up in them cannot be generated or checked instantaneously. Mutual induction or the production of induction currents is due to the fact that differences in the angular velocity of adjacent vortex filaments or cells causes a displacement of the electric particles or idle wheels. Finally, electromotive force is the force causing displacement of the electric particles, and electric currents consist in continuous or periodic movements of these electric particles. Electric currents always produce magnetic fields, because there is nothing of the nature of *slip* between the particles and cells, and, therefore, any progressive movement of the first sets up rotation in the second, and conversely differential rotations or spins of the cells or vortices sets up displacement of the electric particles, causing either electric strain in a dielectric or electric current in a conductor.

3. *Comparison of Theory and Experiment.*—The test of any physical theory is its power to predict new phenomena, or experimental results. The theory of molecular vortices leads to the conclusion that electro-magnetic induction must be propagated through the medium with a finite velocity, and that in dielectrics of unit permeability the velocity of propagation is inversely as the square root of the specific inductive capacity. In the dynamical theory of light it is shown that the ratio of the velocity of light in vacuo to its velocity in any given transparent medium is a constant quantity for each definite wave length, and is called the *index of refraction* of that body for that wave length denoted in physical optics by the symbol μ. Hence, the velocity of light of definite wave length is inversely as the refractive index for that wave length. The refractive index for very long wave lengths can be calculated from observed values of μ for definite rays, and hence numbers obtained representing the relative velocity of light in various transparent bodies. The values of the *dielectric constants*, or reciprocal of the electric elasticities, of various transparent and semi-transparent bodies have also been determined, and it has been found that for a large group of bodies there is a tolerably close agreement between the values of the square root of the dielectric constant and the index of refraction $\mu\infty$ for very long waves, as shown by the selection from the results of some experimental determinations given in Table A.

For some other dielectrics, such as glass and the vegetable and animal oils, the agreement is not by any means so close, but for gases as determined by Boltzmann (*Pogg. Ann.* CLI., 1875, p. 403), there is a fair coincidence. (See Table B.)

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TABLE A.

K (Dielectric Constant).	$\sqrt{K}$	$\mu\infty$ (Refractive Index).	Authority.	Reference.
Sulphur .....3·84	1·96	2·04	Boltzmann	*Pogg. Ann.* CLI. 1874, p. 482.
Colophonium.....2·55	1·59	1·54		
Paraffin .....2·32	1·52	1·54		
Pure Rubber.....2·12	1·45	1·50	Schiller	*Pogg. Ann.* CLII., p. 535.
Oil of Turpentine 2·21	1·49	1·46	Silow	*Pogg. Ann.* CLVI., 1875, p. 395.
Petroleum .....2·037	1·43	1·46		
Benzene .....2·198	1·48	1·48		
Petroleum Spirit 1·92	1·38	1·38	J. Hopkinson	*Trans.* Roy. Soc. 1877, 1878 and 1881.
Petroleum Oil ...2·07	1·44	1·44		
Ozokerite .....2·13	1·46	1·44		
Turpentine .....2·23	1·49	1·46		

TABLE B.

Gas.	K	$\sqrt{K}$	μ
Air.....	1·00059	1·000295	1·000294
Carbonic acid	1·000946	1·000473	1·000449
Hydrogen	1·000264	1·000132	1·000138
Carbonic oxide.....	1·000690	1·000345	1·000340
Nitrous oxide	1·000994	1·000497	1·000503
Olefiant gas	1·001312	1·000656	1·000678
Marsh gas	1·000944	1·000472	1·000443

TABLE C.

Substance.	K	$\sqrt{K}$	$\mu\infty$ (approx.)
Glass, extra dense flint	9·896	3·1	1·5 to 1·6
„ light flint	6·72	2·59	
„ crown	6·96	2·63	
„ plate	8·45	2·90	
Castor oil	4·78	2·18	1·46
Sperm „	3·02	1·73	1·46
Olive „	3·16	1·77	1·46
Neatsfoot oil	3·07	1·75	1·45

The gases are taken at 0° C and 760 millimeters pressure. Accordingly, we can say that for a large group of dielectrics, of which the magnetic permeability is unity, and hence the velocity of propagation of an electro-magnetic impulse proportional to the square root of the electric elasticity or to the reciprocal of the square root of the dielectric constant, we do find a fair agreement between these numbers and the numbers representing the refractive indices or the relative velocities of propagation of very long waves or disturbances in the ethereal medium postulated to account for the phenomena of light. The imperfect agreement between the values of refractive index for long wave lengths and the square foot of the dielectric constant for some other bodies shows that the theory is only approximately in agreement with fact, and that the results obtained by the methods adopted for determining the dielectric constant are perhaps impure, and do not give the true value of the electric elasticity. When we consider that the displacements which constitute the light wave motion of the luminiferous ether are changed some billions of times per second, it is seen to be highly probable that measurements of the specific inductive capacity in which the electric stresses are only reversed tens or hundreds of times in a second may be rendered impure or mixed owing to the presence of effects due to an imperfect electric elasticity introduced by the superposition of electric conduction or of electrolytic transport upon the true or elastic displacement effect. In fact those bodies, such as glass and the vegetable oils, which exhibit the greatest discrepancy are those in which the chemical composition indicates a possibility of electrolysis. There may be an electric displacement in such electrolysable bodies over and above the true electrostatic displacement which is engendered by a molecular change in the body, which change results in actual decomposition when the electric force reaches a certain limit. Put broadly, it may amount to this, that the true electric displacement is a displacement of electricity within the molecule, but that in electrolysable bodies electric stress sets up a strain of the molecule itself which, within certain limits, is an elastic strain, and disappears with the removal of the stress, but that beyond these limits molecular disruption takes place. In these cases the displacement measured in taking the specific inductive capacity is the true or dielectric displacement *plus* a displacement due to strain of the molecule, and the result would be to make K appear too great, and, in fact, for glass and certain oils the values in Table C have been obtained, which in all cases are such that $\sqrt{K}$ exceeds the value of $\mu\infty$ or the refractive index for very long waves of light.*

(*To be continued.*)

THE RESISTANCE OF ELECTROLYTES TO THE PASSAGE OF VERY RAPIDLY ALTERNATING CURRENTS.†

BY PROF. J. J. THOMSON, M.A., F.R.S., CAVENDISH PROFESSOR OF EXPERIMENTAL PHYSICS, CAMBRIDGE.

The electromagnetic effect of the currents induced in a conducting plate by alternations in a primary electromagnetic system in its neighbourhood, is, at a point on the side of the plate opposite to the primary system, in the contrary direction to the electromagnetic effect of the primary. Such a plate, therefore, tends to shield off from a secondary system the induction due to the primary, the diminution it produces in the current induced in the secondary depending upon the conductivity and thickness of the plate and the rate of reversal of the primary current. If the rate of reversal is infinitely rapid, a thin plate of very badly conducting substance will be sufficient to screen off from the secondary circuit all the induction arising from the primary, while if the rate is very slow, a thick plate of the best conducting metal will hardly be sufficient to do this. When the current in the primary is reversed a few hundred times per second, a metal plate of very moderate thickness will completely shield off all induction. If the thickness of the plate exceeds this limit, the currents induced in the layers next the primary will shield off all electromotive force from those layers which are more remote, so that in these layers no currents will be formed; the induced currents will thus be confined to the skin of the conductor, the thickness of the skin varying inversely as the conductivity of the plate and the rate of reversal of the current.

In Hughes' induction balance this screening effect of metal plates is made use of to compare the resistances of two metals, but with that apparatus it is hardly possible to make the alternations sufficiently rapid to produce appreciable effects with substances which conduct so badly as electrolytes; we can, however, by employing the vibrations of electrical systems such as those used by Hertz in his recent experiments on the rate of propagation of electrodynamic, action get oscillations sufficiently rapid to make the shielding effect of moderately thin plates of electrolytes quite appreciable. . . . .

The general mathematical theory is then developed, and it is shown that if with the same rate of reversal two different plates produce the same effect upon the induced current, their thicknesses must be proportional to their specific resistances, or, in other words, the resistance of slabs of the same area to currents parallel to their bounding surfaces must be the same. . . . The rapidly alternating-currents, which in the experiments were screened by the plates, were those resulting from the electrical vibrations which are set up when the electrical equilibrium of a system is disturbed. . . . The rate of propagation of a disturbance through a conductor is only equal to that of the electrodynamic action through a dielectric under certain ascertained mathematical relations, and though this will be so for the rapid vibrations we are dealing with when the conductor is metallic, it would not be so if the conductor were a dilute electrolyte or a rarefied gas. In this case the rate of propagation of the disturbance through the conductor would not be the same as that through the dielectric. In this case the action propagated along the conductor and that propagated through the dielectric would, when they met, interfere and set up standing vibrations, so that along the conductor there would be a series of stationary nodes at which the current vanished—in other words, the current along the conductor would be striated. In the discharge of electricity through rarefied gases we have the current passing through a conductor of high resistance, and it seems possible that the striations which are observed in the case may be due to the interference of the disturb-

* *See* Dr. J. Hopkinson, *Phil. Trans.* Roy. Soc., Vol. CLXXII., 1881, p. 372.

† Abstracted from the *Proc.* Roy. Soc., Vol. XLV., No. 276. The original Paper also includes an elaborate mathematical investigation on "The Times of Vibration of Electrical Systems."

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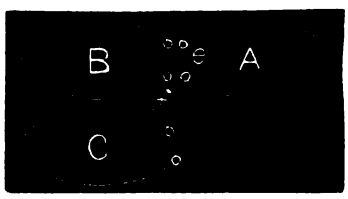
ance propagated through the conducting gas and that passing through the dielectric. The widening of the striæ on rarefaction, and on increasing the diameter of the discharge tube, are consistent with this view.

The resistances of the electrolytes to the very rapidly alternating-currents were compared in the following way :—



A, B, C are three coils, two of which (B and C) are approximately of the same dimensions, and are nearly but not quite closed. Spherical balls are fastened to the ends of these coils. The two balls of the coil C are supported in an ebonite frame provided with an ebonite screw, by means of which the two balls can be brought very near together and kept so as long as is necessary.

The coils B and C are placed on shelves of glass coated with shellac. The shelves are supported on a framework with supports at different levels, as in an ordinary book-case, so as to enable the distance between the primary and secondary coils B and C to be altered if necessary. The coil A is connected to an induction coil which, when in good order, will give sparks five or six inches long. The coil is worked by a slow mercury break, the speed of which can be regulated by altering the inclination of the arms of a fan whose motion resists that of the break : in the actual experiments the circuit was broken every few seconds. When the coil works sparks pass between the points *e* and *f*, electrical vibrations are started in the coil B ; in other words, there are alternating currents in B whose period is that of its electrical vibration, and given by equation (18). The currents in B will induce currents in C, and these latter will be rendered evident by the production of a minute spark between the two balls at its extremities. These sparks, though small, are so bright that they can be readily observed without darkening the room.

The production of sparks in the secondary circuit is much affected by what are, apparently, slight alterations in the conditions of the primary. Thus, for example, it is very much facilitated by placing the balls of a pair of discharging tongs between *e* and *f*, and allowing the spark to jump from *e* to the discharging tongs, and then from the discharging tongs to *f*. This change did not seem to be due to the resonance between the coils B and C being improved by the presence of the tongs, for unless they were placed in the way of the spark they produced no effect ; again, it was not altogether due to an increase in the quality of electricity which passed from A to B at each discharge, as this was measured by placing a specially insulated galvanometer in the circuit, and it was sometimes found that the quantity of electricity which passed when the tongs were not interposed, and when no spark was produced in the secondary circuit, was greater than the amount which passed when the tongs were interposed and when sparks were produced. The character of the spark which passes between A and B has also great influence—the best sparks are those which are perfectly straight, and accompanied by a sharp snap ; zigzag sparks in the primary very rarely produce any sparks in the secondary.

A conducting plate placed between B and C ought, as we have seen, to diminish the induction between them, and therefore the electromotive force in the current C, and since the diminution in the induction increases with the rapidity with which the current in the primary is reversed, it ought in this case to be very marked. This was found to be the case ; thin sheet metal and tin-foil when placed between the coils were found to completely stop the sparks in C. I then coated a plate of glass, which of itself had no effect upon the sparks, with a film of Dutch metal about $\frac{1}{1700}$ of a centimetre in thickness, and found that it completely stopped the sparks, and I have not been able to get a film of metal thin enough to allow sufficient induction to pass through to produce sparks in the secondary. . . .

A thick plate of ebonite was next placed between the coils, but did not produce any appreciable diminution in the sparks in the secondary ; thus ebonite, though opaque to the vibrations as rapid as those of light, still allows vibrations of which 10^8 take place in a second to pass through without interruption.

The effect of interposing a film of electrolyte was next tried. A large square glass trough was placed between the coils B and C, and carefully levelled, the electrolyte was then poured in ; when only a very small quantity of electrolyte was in the trough the sparks still passed, but they got feebler and feebler as the quantity of electrolyte in the trough increased, until finally, when the electrolyte was dilute sulphuric acid, they ceased altogether when the depth of the electrolyte in the trough amounted to three or four millimetres. The criterion adopted for the disappearance of the sparks was to allow 60 sparks to pass into the primary, stopping and starting the coils several times ; if, during this time, no sparks passed in the secondary, the sparks were considered stopped. A variation of 5 per cent. in the quantity of electrolyte present would cause the system to pass this point one way or another in a marked way.

The balls at the extremity of the secondary were adjusted so that sparks passed freely before the electrolyte was put in, after each experiment the electrolyte was removed, and care was taken to ascertain that sparks still passed as freely as before, so as to guard against any accidental disarrangement of the secondary during the experiment.

Three sets of coils were used which we shall describe by I., II., III. Set I. consisted of two circular brass coils, 140·8c. in circumference. The diameter of the brass rod of which they were made was about 0·6c. ; the balls at the extremities were 2c. in diameter. The time of vibration of this coil, calculated by equation (18), is about 10^{-8} seconds.

Set II. consisted of two circular copper coils 81·2c. in circumference, the rod of which they were made being about 0·5c. in diameter ; the balls at the extremities were 1c. in diameter. The time of vibration is about 5×10^{-9} seconds. With these small coils the balls of the secondary had to be exceedingly close together in order to get sparks, but when the micrometer screw was properly adjusted the sparks were very bright and the indications quite definite. The coils were about 9c. apart.

Set III. consisted of two rectangular coils made of sheet lead, one side was 30c., the other 40c., the breadth of the sides was 5c., and the diameter of the balls at the extremity 2c. The distance between the coils was 15c. The time of vibration about 10^{-8} seconds.

The electrolytes used were solutions of—

Sulphuric acid,	specific gravity of	solution	.....	1·175
Ammonium chloride	,,	,,	.....	1·072
Sodium ,,	,,	,,	.....	1·185
Potassium ,,	,,	,,	.....	1·155
Ammonium nitrate	,,	,,	.....	1·175
Potassium carbonate	,,	,,	.....	1·280

In the following table the relative thickness of the films of these substances required to stop the spark is given, each number being the mean of several observations. The thickness of the H_2SO_4 film was taken as unity. An observation with sulphuric acid was made before and after the observation with any other electrolyte.

	H_2SO_4.	NH_4Cl	NaCl.	KCl.	NH_4NO_3.	K_2CO_3
Coil I.	1	1·45	2·4	2·5	1·6	3·1
Coil II.	1	1·5	2·5	3·3	1·9	3·1
Coil III.	1	1·63	2·75	3·2	2·0	3·3
Mean	1	1·53	2·55	3·0	1·8	3·2
Relative resistance with very slow reversal	1	1·65	3·0	3·4	1·8	2·8

The thicknesses of the films are proportional to the specific resistances, so that the numbers in the fourth line give the relative resistance of the electrolytes to currents whose directions are reversed from 10^8 to 2×10^8 times per second. In order to see whether these resistances are the same as those with an almost infinitely slower reversal, I determined the resistance of the electrolytes by using a commutator which reversed the current through the electrolyte about 120 times a second, and kept the direction of the current through the galvanometer constant. The electrodes were platinised, and no polarisation could be detected. The numbers are given in the last line of the above table, and agree sufficiently well to enable us to say that the relative resistance of electrolytes is the same when the current is reversed a hundred million times a second as for steady currents.

It was not possible to compare in this way the resistances of electrolytes and metals, as the thinnest metallic film which could be obtained was evidently much thicker than was necessary to completely stop all induction. I succeeded, however, in comparing by this method the resistances of graphite and sulphuric acid, The graphite film was prepared by placing a sheet of glass at the bottom of a trough filled with water, holding a large quantity of finely powdered graphite in suspension ; after the graphite had deposited itself uniformly on the glass plate, the water was syphoned off, and the graphite film allowed to dry gradually. When quite dry it was hard and compact, and could be rubbed down by emery to any required thickness. By diminishing the thickness of the film and adjusting the distance between the coils, a film of graphite was obtained which just stopped the sparks ; a film of H_2SO_4 was then substituted for the graphite, and its thickness adjusted until it, too, just stopped the sparks. In this case the resistance of equal and similar areas of

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the two films to currents parallel to their surface must be the same, the currents being reversed 10^8 times per second. I determined the resistances to steady currents parallel to the surface, and found that the resistance of the graphite film was 6·7 ohms, and that of the sulphuric acid 7·2 ohms; thus we may say that the ratio of the specific resistances of graphite and sulphuric acid is the same when the currents are steady as when they are reversed 10^8 times per second. Since the ratio of the resistances of such dissimilar things as graphite and electrolytes remains the same, we may conclude that the resistances themselves remain unaltered. The method described above for comparing the resistances of electrolytes is one that can be very easily and quickly applied, and only requires the simplest apparatus: an induction coil, or, if that is not available, an electrical machine, being all that is required. The method has the advantage of avoiding the use of electrodes, as all the circuits in the electrolyte are closed.

Since electrolytes are transparent, they must, if the electromagnetic theory of light is true, act as insulators when the currents are reversed as often as light vibrations, or about 10^{15} times per second. We have seen, however, that they conduct as well when the currents are reversed 10^8 times a second as when they are steady; thus the molecular processes which cause electrolytic conduction must occupy a time between 10^{-8} and 10^{-15} seconds.

Another point which can be settled by this method is, whether a vacuum is a conductor or an insulator. According to one view the great resistance which a highly exhausted vessel offers to the passage of electricity is due to the difficulty of getting the current from the electrode into the rarefied gas. When once the current has got there there is, according to this theory, no further resistance to its passage. If this theory is correct, a highly exhausted receiver placed between the primary and secondary circuits ought to stop the sparks in the latter, as since all the circuits are closed there ought to be no obstacle to the passage of the induced currents. In order to test this I took a box, 50c. by 50c. by 4c., the top and bottom of which were sheets of plate-glass fitting into wooden sides; the sheets of glass were also supported by five ebonite pillars placed at equal intervals over their surface. The box was repeatedly dipped into a bath filled with melted paraffin until it was surrounded by a coating of paraffin about 2c. thick. The paraffin was then smoothed over with a hot soldering iron, and then covered with a layer of shellac varnish. The box was then exhausted by a mercury pump, and it was found that the pressure could be reduced to about 1mm. of mercury, but no further. When this vacuum was placed between the primary and secondary coils it did not produce the slightest effect upon the sparks, so that its conductivity must be very small indeed compared with that of the electrolytes used in the preceding experiments. I am having an earthenware vessel made with which I hope to repeat the experiment at much higher exhaustions.

I also tried whether the conductivity of the electrolyte was altered by sending a current through it; for this purpose a layer of sulphuric acid was placed between the primary and secondary coils of such thickness that it almost but not quite stopped the sparks in the latter; a current of about two amperes, which was reversed about 500 times a second, was then sent through the sulphuric acid, but the passage of the current did not seem to produce any effect whatever upon the sparks in the secondary. I conclude, therefore, that the resistance of an electrolyte is not affected by the passage of a current.

I wish to express my thanks to my assistant, Mr. E. Everett, for the zeal and skill he has displayed in these experiments.

[*Note added February* 15, 1889.—I have recently tried the effect of a very high vacuum in stopping the sparks. The primary circuit consisted of two straight wires with spheres fastened to one end of each; these wires were connected with the poles of an induction coil, and the sparks passed between the spheres. The secondary consisted of two similar wires, with smaller balls at the ends, the distance between the balls being very small. The length of the wires of the secondary was altered until it was in resonance with the primary. The secondary was placed in a hollow cylinder formed of two coaxial glass tubes, sealed on to a mercury pump, by means of which a very high vacuum was obtained in the space between them, which surrounded the secondary. This vacuum, however, did not produce the slightest effect on the sparks.]

REVIEWS.

Projet d'Utilisation de la Puissance d'une Chute d'Eau pour l'Eclairage Electrique d'une Ville. By L. Vigreux, Ingénieur Civil. Chevalier de la Légion d'Honneur, &c. (Paris: Bernard et Cie., 1889.)

In the neighbourhood of a town of 20,000 inhabitants there is a waterfall some 60 feet in height; it is proposed to utilise the energy of the fall for lighting the streets by electricity. Such is the problem elaborately discussed by M. Vigreux in the work before us. The volume is accompanied by a separate portfolio containing 15 sheets of drawings, each 24in. by 20in.

For a monograph of this nature to be of any real use there would appear to be just one necessary and sufficient condition—it must be the work of a thoroughly practical man, and in that case it will also be the outcome of practical experience. Now, if we may judge from the volume before us, the author, although he is undoubtedly a distinguished Professor of Mechanics, has never had the opportunity of carrying out a scheme such as he here unfolds. One reason we have for saying this is that in any actual case the element of cost would undoubtedly enter into the question. But except for the elaborate pretence of working out the application of Thomson's law the designs are laid before us "utterly regardless of expense." M. Vigreux proposes to connect his 340 arc lamps *in parallel* on four circuits. He has novel and original (and very expensive) ideas for maintaining constancy of potential, and he seems to be unaware that arc lamps joined in parallel require a supplementary resistance in each branch. This is probably enough to convince the English reader that the work is lacking in the only *raison d'être* which we could imagine it to possess; but we wish to pursue the indictment somewhat further.

To say that no opportunity for mathematical display is ever omitted is merely to say that it is thoroughly French. This we could the more easily forgive because equations can so easily be skipped; but we find it more difficult to pardon a writer, who is presumably addressing a technical audience, for insisting on the most minute and elaborate definition of every single technical term made use of. Even in France we should suppose that nobody would come to a book like this to learn for the first time what an incandescent lamp is like, or that a dynamo is a machine for the conversion of mechanical into electrical energy. If it should appear that in making these strictures we are only slaying the already slain, we must plead that these are vices which, to a greater or less extent, run through the whole of French and German technical literature, and that so noteworthy an example, by so distinguished an author, affords an excellent opportunity for giving vent to one's feelings of exasperation which have been long and steadily accumulating. The continental writer on electrotechnics usually reminds us of the historian who, in his seventh chapter, arrived at the epoch of the creation. In the book before us, the opening sentences tell us that "all bodies, solid, liquid, or gaseous, are supposed to be constituted by an assemblage of very small elements of material points of finite mass," &c. After this we have page after page devoted to the equations of motion, to the theorem of Greene, and to definitions of mechanical and electrical units. It seems strange on turning the leaf to be confronted by a long list of streets (the author has evidently selected some existing town) with their lengths and widths minutely tabulated. But after this practical interlude we are again plunged into a pedantic disquisition on the distribution of light—a subject, by the bye, on which the author is much better informed than on his subject proper—the distribution of electricity.

The best part of the book is that devoted to the description of the dynamos—which, it appears, the engineer is expected to build for himself. Excellent working drawings of an Oerliken dynamo are given, and the calculations, although they begin absurdly enough, after a certain point become quite sane and intelligible. It is pretty clear that the author has obtained some information from the Oerliken Works which he first tried to improve on, and afterwards incorporated *en bloc*.

In conclusion, we can only express our unbounded astonishment that so elaborate and expensive a publication should fall so grievously short of its ostensible aim. The volume reads more like a weak but ambitious prize essay than an engineering treatise; and if this was really its genesis it seems a pity that the prize was ever awarded.

"Supplement to Carpmael's Patent Laws of the World." (London: William Clowes and Sons. 1888.)

The preface states that this volume "has, by the wish of the Institute of Patent Agents, been prepared by a Committee of Fellows of the Institute with the object of bringing down to the

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latest date precise information as to the various legal enactments in foreign countries and the colonies." The work consists in textative reproductions of the patent laws of 23 countries, and is without doubt a most valuable and labour-saving addition to the original work of Messrs. A. and E. Carpmael, published in 1885, and well known to all patent agents. The present volume, of course, appeals only to those actively engaged in the profession, or whose business it may be to be informed on the subject; to others it will naturally be without interest.

The preface states that "Mr. Edward Carpmael, as one of the Committee of the Institute of Patent Agents, has devoted much time and labour to the preparation of the work, and to his energy and ability the issue of the present volume is largely due." There can be no doubt as to the time and labour, and from the source and auspices of the work it should be accurate.

Glimpses of Feverland; or a Cruise in West African Waters. By Archer P. Crouch, B.A. (London: Sampson Low, Marston, Searle and Rivington, 1889.)

The author of "On a Surf-bound Coast" is sure to meet with a warm welcome from every reader of his earlier volume. The story of the laying of the cable from St. Paul de Loanda to St. Thome is interesting enough in itself, but this is subordinated to the description of the writer's personal adventures on the way from Sierra Leone in a coasting steamer, and on various trips to and fro amongst the ports and islands of the Gulf of Guinea. The easy, unaffected style of the narrative, the continual flow of incident, sometimes trivial but always entertaining, and the admirably-drawn pictures of life and scenery in a region little known, contribute to make this a really delightful book. Once begun it will be read from end to end, and finally laid down with something like regret.

THE PHYSICAL SOCIETY.

At the meeting of this Society, held on the 9th inst., Prof. Oliver J. Lodge read a Paper on

"The Rotation of the Plane of Polarisation of Light by the Discharge of a Leyden Jar."

The author pointed out that electrical effects depending on the total amount of a current and not upon its duration, such as induction currents, magnetisation, and rotation of the plane of polarisation, can be well produced by means of the Leyden jar discharge.

When a beam of polarised light is sent through a piece of heavy glass or a tube containing bisulphide of carbon, and the analyser is so adjusted as to give the maximum extinction, a sudden appearance of light is observed when a Leyden battery is discharged through a coil surrounding the glass or tube.

The oscillatory nature of the discharge and the consequent oscillatory restoration of light in the dark field is conclusively demonstrated by the fact that a small rotation of the analyser in either direction from the position of maximum extinction has the same effect on the result, and also by the fact that the sensitive tint of a bi-quartz is unaffected by the discharge.

The experiment seems to show that the effect is practically instantaneous, a conclusion which is at variance with the conclusion deduced by Villari ("Rendiconto del Istituto Lombardi," Ser. II., Vol. III., translated in *Poggendorff's Annalen*, Vol. CXLIX.) from observations on a drum of heavy glass rapidly whirled between the poles of a magnet. Villari found that the rotation of the plane of polarisation diminished as the speed increased, and almost entirely disappeared when a speed of about 180 revolutions a second was attained, from which he concluded that a time between $\frac{1}{800}$ and $\frac{1}{400}$ of a second was required to produce the effect.

In 1882 Messrs. Bichat and Blondlot had made a series of beautiful experiments (*Comptes Rendus*, Vol. XCIV), from which they concluded that if time were required to produce the effect it could not exceed $\frac{1}{30000}$ of a second. Professor Lodge observed that the investigation contained in his Paper consisted practically in a repetition of their results with the working out of the theory.

In order to determine whether any perceptible time was required for the effect, the two French physicists allowed the light traversing the tube to illumine a slit, while a second slit immediately above the first was illuminated by the spark of the discharge causing the rotation. The light passing through both slits was spread out into discontinuous bands by means of a revolving mirror, and the serrations in the two bands were found to agree exactly, as far as could be observed, showing that no perceptible time was required for the production of the effect. They also mentioned an experiment made by Messrs. Curie and Ledeboer, in which no diminution was observed in the effect in the case of a disc of glass spun, like a Foucault copper disc, between the poles of a magnet. Professor Lodge finds from his own experiments that the sulphide of carbon shows the effect when the rate of alternation is as high as 70,000 in a second. The oscillatory character of the effect was then exhibited to the Society by allowing the polarised beam which had traversed the sulphide of carbon to fall upon a rotating mirror, after adjusting the analyser to give the maximum extinction possible. A faint band of light was thus obtained, which was observed to become brighter and assume a distinct beaded appearance at every discharge round the tube. When the analyser was slightly rotated in either direction every alternate bead became fainter, while the remaining ones became brighter, which distinctly demonstrated the oscillatory character of the light.

Theory of the Effect.—The current at any instant is given by the equation

$$C = \frac{V_0}{pL} e^{-mt} \sin pt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $$m = \frac{R}{2L} \quad \text{and} \quad m^2 + p^2 = \frac{1}{SL},$$

S being the electrostatic capacity of the circuit, L its coefficient of self-induction, R its resistance, and V_0 the initial potential difference.

Again, the magnetic potential difference between the ends of a tube of length l, containing a substance of magnetic susceptibility μ, and surrounded by a very long solenoid containing n_1 turns of iron wire per unit length and traversed by a current C, is

$$4\pi\mu \, C n_1 l.$$

Calling the Verdet constant, or the rotation per unit difference of magnetic potential, for sulphide of carbon k, the total rotation will be

$$\theta = 4\pi k n_1 l \mu C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Let a be the total amplitude of the light falling upon the analyser, then the component transmitted when the analyser is set to extinction, supposing this to be complete, will be $a \sin\theta$, and the amount of light transmitted during a time τ for which an impression is capable of being accumulated on the retina will be $\int_0^\tau (a \sin\theta)^2 \, dt$. The amount of light passing during the same time with the analyser set to maximum brightness, supposing all the light transmitted, will be $a^2\tau$, so that

$$B = \frac{\text{apparent brightness restored by spark}}{\text{maximum possible brightness}} = \int_0^\tau \frac{a^2 \sin^2\theta \, dt}{a^2 \tau} = \frac{1}{\tau}\int_0^\infty \sin^2\theta \, dt \quad . \quad . \quad . \quad (3)$$

approximately, since τ is very great compared with the duration of the discharge. When θ is small this may be evaluated in the form

$$B = 160 k^2 n_1^2 \frac{\frac{1}{2} S V_0^2}{R\tau} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Its general value is

$$B = \frac{1}{2m\tau}\int_0^\Lambda \frac{1 - J_0(x)}{x} dx.$$

Where J_0 is the first Bessel function, and

$$A = 8\pi k n_1 \mu V_0 \sqrt{\frac{S}{L}}$$

Numerically it comes out from the equations that though the rotation must be very great, probably from 60° to 180°, the restoration of light is only some ten thousandth of what would be obtained by rotating the Nicol prism. This explains why it is easy to analyse the restored light into a beaded band, for here the effect of the separate oscillations are obtained, and these are very bright though momentary.

The formulæ show that to get large effects a large battery, charged to a high potential, should be employed, the latter, however, being limited by the condition that it must not be sufficient to endanger the coil.

They show, moreover, that the addition of self-induction is indifferent, the reason being that while it diminishes the effect of each oscillation it prolongs its duration, and has no effect on the total action; and they also show that increased resistance diminishes the effects.

Prof. Lodge thought that Villari's results might have been due to a state of strain being set up in the glass by the centrifugal force, though, in that case, a similar effect ought to have been produced in the absence of a magnetic field, which Villari says was not the case. Professor Lodge, however, pointed out that if there

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were no magnetic rotation the aspect of the plane of polarisation, with respect to the direction of the stress, would remain constant, which would not be the case when there was magnetic rotation. This might possibly lead to an explanation, though he did not understand how the change of aspect could diminish the rotation instead of giving rise to elliptic polarisation.

DISCUSSION.

Mr. WARD said he had been experimenting in the Cavendish Laboratory on the subject of Villari's experiment. He had constructed apparatus similar to Villari's, and he found that the bi-quartz underwent changes in colour, indicating elliptic polarisation. This would make it impossible to observe a change in the plane of polarisation. Villari ought to have recognised this fact, which accounted for the extreme irregularity in the results recorded in his tables, an irregularity which he himself attributed to the difficulty of maintaining the speed of rotation constant. When a state of strain was set up in the disc there would be a rotation of the plane of polarisation, together with elliptic polarisation. In the case of an elliptically-polarised beam the effects of rotating the plane of polarisation by the action of a magnetic field was to shift the axes of the ellipse. He used a pair of crossed Nicol prisms in his experiments, and an alternating current of high frequency. He suggested that it would be desirable to use a dynamo, an alternating current of high frequency to be sent round the glass. He considered that the mathematical examination of Villari's paper showed that it was of very little value, owing to his having completely overlooked the fact that strained glass causes elliptic polarisation.

Prof. RUCKER referred to a paper by Dr. Cook "On the Existence of an Undulatory Movement Accompanying the Electric Spark,"* read before the Society on June 23rd, 1888, and to an experiment of Dr. Guthrie's which he had exhibited in connection with it at the same meeting, in which the discharge of an electric spark at one of the foci of an elliptic tray gave rise to ripple marks on the surface of the tray, which had been previously sprinkled with some powdered substance. He thought that this result, as well as the results observed by Dr. Cook, were due to air ripples produced by the electrical oscillations. The electrical vibrations in the case of the experiment with the elliptic tray would be something like a million a second, and the distances between the ripple marks were about what would be produced by the corresponding oscillatory motion excited in the air. He considered it an interesting fact that heavy glass and sulphide of carbon behaved in the same manner in Prof. Lodge's experiments, as there were differences in their behaviour as regards electrical stress.

Prof. LODGE stated that he did not assert that the actions were numerically identical, as he had not sufficient data at his command to warrant it. He had hitherto only had a small piece of glass to experiment with, and, therefore, he could only assert a general similiarity in the behaviour of the two substances. He said that Prof. Rücker's idea had occurred to Mr. Chattock, his assistant, and he had made some experiments. The ripples obtained were about a millimetre apart, and the frequency of electrical oscillations required to give air waves of this length came out to about the value anticipated theoretically.

Prof. AYRTON said that Prof. Perry and himself, in investigating the E.M.F. curve of an alternating dynamo, had employed a method for detecting oscillations too rapid for the eye to follow, which might be of use in the present investigations. To the receiving membrane of an Edison phonograph of the old type they attached a small coil which was traversed by a steady current. Near to this was placed a fixed coil carrying the alternating current. The vibrations due to the variation in the mutual attraction of the two coils were thus recorded on the tinfoil, the machine being made to rotate rapidly. If the cylinder were then made to rotate more slowly an audible note might be obtained. In their experiments they took out the receiving membrane, replacing it by a transmitter to which they had attached a magnifying spring giving one complete rotation of the pointer for an extension of $\frac{1}{100}$ of an inch, and having a mirror attached to it. The tinfoil was then turned through a measured angle and the rotation of the pointer observed, and in this manner they were able to get all the ripples on the wave.

Prof. Lodge then exhibited an experiment analogous to some of Dr. Hertz's, illustrating Electric Resonance.

The sparks from a Holtz machine were made to pass between two brass balls at a small distance apart. In front of the air space traversed by the sparks was placed a resonator which had been tuned to electric unison with the circuit of the Holtz machine. This resonator consisted of a pair of condenser plates placed at a short distance apart and nearly touching at one edge, so as to allow of a spark passing, the plates being joined by means of a gutta-percha covered wire. Sparks were then seen to pass between the condenser plates when the machine was in action. It was then shown that the insertion of additional self-induction in the resonator circuit caused a cessation of the sparks by throwing it out of unison with the exciting circuit.

A Dictionary of Electrical Terms.—We learn that "A Dictionary of Electrical Words, Terms, and Phrases," by Prof. E. J. Houston, will shortly be brought out by the *Electrical World* of New York.

* *The Electrician*, December 28th, page 224.

RELATIVE AMOUNTS OF VOLTAIC ENERGY OF DISSOLVED CHEMICAL COMPOUNDS.*

BY G. GORE, LL.D., F.R.S.

In this investigation the author has measured by the "voltaic-balance" method the amounts of relative voltaic energy or of chemical affinity for zinc, of nearly 250 aqueous solutions of chemical compounds, including those of elements with elements, elements with monobasic, bibasic, and tribasic acids, acids of all these classes with each other, elements with monobasic, bibasic, tribasic, and tetrabasic salts, monobasic, bibasic, and tribasic acids with all these classes of salts, and all these classes of salts with each other in large variety; and he offers the results as additional evidence in support of the conclusion that "*every electrolytic substance or mixture when dissolved in water unites chemically in definite proportions by weight with every other such dissolved body*, provided no separation of substance occurs;" and that "there may probably be discovered thousands of such compounds which only exist whilst in aqueous solution, and are decomposed on evaporating or crystallising their solutions" (Roy. Soc. *Proc.*, Vol. XLIV., p. 267). The results are given in the form of a volta-tension series of electrolytes.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, March 22nd.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "The Cyclical Velocity Fluctuations of Steam and other Engines." By H. B. RANSOM, Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "The Science of Animal Locomotion in its Relation to Design in Art." (Illustrated by the zoopraxiscope.) By EADWEARD MUYBRIDGE.

SATURDAY, March 23rd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

PHYSICAL SOCIETY.

3 p.m. "On the use of Lissajou's Figures in the Maintenance of Uniform Rotation," and "On the Direct Determination of the Vibration Period of a Reed or Tuning Fork by means of a Morse Receiver." By Prof. J. V. JONES. "On the Clark Cell as a Source of Standard Currents." By Prof. R. THRELFULL and A. POLLOCK. "On the Measurement of High Specific Resistance." By Prof. R. THRELFULL.

MONDAY, March 25th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture V., 1. "Instruments for the Measurement of Radiant Heat." By C. V. BOYS, F.R.S.

TUESDAY, March 26th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "The District Distribution of Steam in the United States." By C. E. EMERY, M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. "Borneo." By ROBERT PRITCHETT.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture.—Part II. "The History of a Crime Unravelled by a Piece of Rusting Iron, a Horseshoe and a Match." By Prof. H. E. ARMSTRONG.

WEDNESDAY, March 27th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Adjourned Discussion on Prof. Kennedy's Paper, "The Objects and Methods of the Society of Arts' Motor Trials."

THURSDAY, March 28th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Houses and Their Decoration from the Classical to the Mediæval Period." By Prof. J. HENRY MIDDLETON, M.A.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Paper not decided on.

* Abstract of a Paper read before the Royal Society, March 14, 1889.

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The Electrician.

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CONTENTS OF THE CURRENT NUMBER.

NOTES 555
Notes on Electro-Magnetic Induction. By Dr. J. A. Fleming, M.A. Continued. . 560
The Resistance of Electrolytes to the Passage of very Rapidly Alternating Currents. By Prof. J. J. Thomson, M.A. Illustrated 561
Reviews 563
Physical Society.—"The Rotation of the Plane of Polarisation of Light by the Discharge of a Leyden Jar." 564
Relative Amounts of Voltaic Energy of Dissolved Chemical Compounds. By G. Gore, LL.D., F.R.S. 565
Meetings of Scientific Societies. 565
ELECTRIC LIGHTING IN THE METROPOLIS 566
The Indian Telegraph Department. 567
Arc Lamps and their Mechanism. By Prof. Silvanus P. Thompson, D.Sc., M.I.E.E. Illustrated. Continued 568
Economics of Planning and Constructing Electric Light and Power Stations. By Alex. P. Wright Continued 572
On an Effect of Light upon the Magnetisation of Iron. By Shelford Bidwell, M.A., F.R.S. 574
Berry's Improved Electric Bell. Illustrated 574
American Notes 575
Scandinavian Notes 576
CORRESPONDENCE—
Prof. Joseph Henry's Researches.—J. A. Fleming... 576
The Theory of the Arc Lamp.—Wilson Hartnell. Illus... 577
On the Designing of Continuous-Current Dynamo Machines—Andrew Jamieson 577
The Holden Hydrometer. Ilus. 578
COMPANIES' MEETINGS, &c.—
Brazilian Submarine Telegraph Company (Limited).. 578
The Western Counties and South Wales Telephone Co. 579
City Notes, &c 579
Companies' Share List 580

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ELECTRIC LIGHTING IN THE METROPOLIS.

IN nearly all the Metropolitan Vestries and District Boards, as well as in half the Municipalities of the kingdom, Electric Lighting Committees are now the order of the day; and although hitherto there has been a great deal of cry and surprisingly little wool, yet the time has at length arrived when the projects for which Provisional Orders have been already applied for must be dealt with in earnest. In this matter the actual responsibility rests chiefly with the Board of Trade, and in so far as the Metropolis is concerned that responsibility is no light one. Questions of the greatest difficulty and delicacy must be dealt with, and to reconcile the competing interests of rival companies, the divergent views of multifarious local authorities, and, at the same time, to safeguard the interests of the private consumer is a task which will demand no small degree of patience and of skill for its accomplishment.

In determining to hold a public inquiry into the merits of the various schemes now in train the Board of Trade have in all probability adopted the most satisfactory course which was open to them. The inquiry will be held under the presidency of Major MARINDIN, at 8, Richmond-terrace, Whitehall, commencing at 10.30 on Wednesday, April 3rd. Ostensibly it is instituted to report upon the various applications for Provisional Orders and Licenses now before Parliament and the Board in respect to the Metropolis, and lodged under the Electric Light-

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EXTRACT FROM THE "ELECTRICAL REVIEW" OF FEBRUARY 8th, 1889.

"Two years ago the Taunton Electric Light Company possessed one dynamo, now it possesses six. On Monday, at the second annual meeting of the Shareholders, a dividend of 6 per cent. was recommended, and next year it is confidently expected that this will be increased. A glance at our City columns will show that the plucky efforts of the directors have been highly successful, and everybody will bear out the assertion of Mr. Potter, that the history of this company is **UNPRECEDENTED IN THE ANNALS OF ELECTRIC LIGHTING** in England. May it go on and prosper!"

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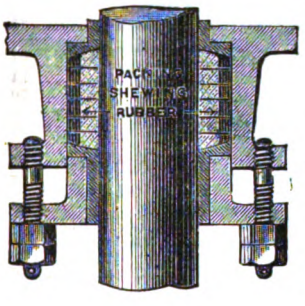

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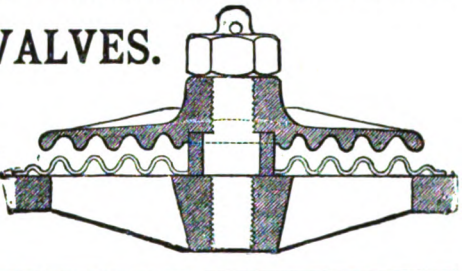

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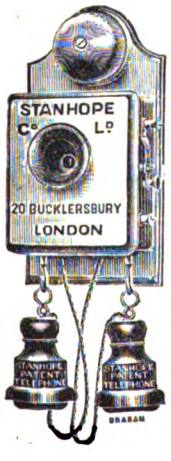

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"THE ELECTRICIAN" INDEX TO ADVERTISERS.

Advertisers in "The Electrician" have their names inserted under the following headings in this Index FREE OF CHARGE.

ACCUMULATORS. PAGE.
Drake and Gorham ..... —
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8

ALTERNATORS.
Anglo-American Brush Co..... 17

AMMETERS.
Nalder Bros. and Co. 16
Sharp and Kent ..... —

ANCHOR & SHIPS' SMITHS.
Moore (W. and E.) 20

ANTI-FOULING COMPOSITIONS.
Kirkaldy (J.) and Son 20

ASBESTOLINE.
Bell's Asbestos Company 22, 23

AUCTIONEERS AND VALUERS (Mechanical).
King (J. W.) 3
Wheatley Kirk, Price and Goulty 3

BATTERIES.
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 13
Latimer Clark, Muirhead & Co. 1

BATTERY JARS.
Joseph Bourne and Sons 2
Cannington, Shaw and Co..... 13
Gent and Co. ..... —
Price, Sons and Co. ..... —
J. Stiff and Sons 20

BELTING.
Balderston and Co. ..... —
Moseley and Sons ..... —
Thompson and Rew ..... —

CABLE COMPANIES.
Anglo-American Telegraph Co. 25
Direct United States Co..... 25
Eastern Telegraph Co..... 26
Eastern Extension Telegraph Co. 26
Indo-European Co. 24

CABLE SUPPLIES.
Latimer Clark, Muirhead & Co... 1
Elliott Brothers 17
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
R. Johnson and Nephew..... 2
Johnson and Phillips 1
Pirelli and Co. 4
M. Theiler and Sons 3

CARBONS.
Anglo-American Brush Co. 17
Barnsley Carbon Co..... 20
General Electric Co. 6
India Rubber & GuttaPercha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 13
C. A. Müller 10
Thompson and Rew (Carré) .... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 7

CASINGS.
McGaw and Co. 10

CUT-OUTS.
Electric Apparatus Co. 2
General Electric Co. 6
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 7

CYCLOSTYLE.
Facsimile Apparatus Co..... 24

DISINFECTANTS.
Sanitas Co..... 16

DYNAMO MANUFACTURERS.
Allen and Co..... —
Anglo-American Brush Co. 17
Blakey, Emmott and Co. 2
Clarke, Chapman, Parsons & Co. 9
Latimer Clark, Muirhead & Co.. 1
Crompton and Co. (Limited).... 12
Edison & Swan United Electric Light Co. 5
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
Holmes (J. H.) and Co. 4
M. Immisch..... 18
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Laing, Wharton and Down 2, 13
Laurence, Paris and Scott (Ltd.) 18
Paterson and Cooper 2
Sharp and Kent..... —
Statter and Co. 2
Thompson and Rew ..... —
United Electrical Engineering Co. 580
Western Electric Co. 18

EBONITE & VULCANITE.
Harburg India Rubber Co. ..... —
D. Moseley and Sons ..... —

ELECTRIC BELLS.
General Electric Co. 6
Gent and Co. ..... —
India Rubber & Gutta Percha Co. 12 16

ELECTRIC BELLS—*(cont.).** PAGE.
Johnson and Phillips 1
King, Mendham and Co. ..... —
London Electric Wire Co. 2
Julius Sax 2
Western Electric Co. 18
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 7

EDUCATIONAL.
School of Electrical Engineering —

ELECTRIC LIGHT.
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co..... 2
Latimer Clark, Muirhead & Co. 1
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 12
Drake and Gorham ..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down (Thomson-Houston) 2, 13
Paterson and Cooper 2
Schmidt-Douglas Electric Co. .. —
Statter and Co. 2
United Electrical Engineering Co. 580
Woodhouse and Rawson (Ltd.).. 7

ENGINEERS & CONTRACTORS
Allgemeine Elektricitäts-Gesellschaft, Berlin 11
Allpress and Belshaw 13
Anglo-American Brush Co. 17
Bernstein Electric Lamp Co.... 2
Booth, Ellson and Co. 11
Latimer Clark, Muirhead & Co. 1
Chamberlain and Hookham 10
Clarke, Chapman, Parsons & Co. 9
Crompton and Co. (Limited).... 12
Drake and Gorham ..... —
Edison and Swan United Co..... 5
Electrical Power Storage Co. .. 19
Elwell-Parker (Limited) 8
Fowler, Lancaster and Co..... 3
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down 2, 13
Laurence, Paris and Scott (Ltd.) 18
Nalder Bros. and Co. 16
Paterson and Cooper 2
Phillips Bros. 2
Julius Sax 2
Schmidt-Douglas Electric Co. .. 3
Sharp and Kent ..... —
J. S. Starnes and Sons 8
M. Theiler and Sons 3
Thompson and Rew ..... —
United Electrical Engineering Co. 580
Verity (B.) and Sons 6
Woodhouse and Rawson (Ltd.).. 7

ENGINE PACKING.
Beldam Packing and Rubber Co. 13
Bell's Asbestos Company 22, 23
J. S. Starnes and Sons..... 8

ENGINES.
Bumsted, F. D. 17
Crossley Bros..... 21
Davey, Paxman and Co. 12
Marshall, Sons and Co..... 3
Priestman Bros 10
Ransomes, Sims and Jefferies .. —
Richards and Co. 4
Statter and Co. 2

EXCESS ALARMS.
Drake and Gorham ..... —

EXPANSION SHEETING AND RINGS.
Bell's Asbestos Company 22, 23

FENCING.
R. Johnson and Nephew 2

FIRE RISKS.
Phœnix Fire Office ..... —

FITTINGS for ELECTRIC LIGHT
Crompton and Co. (Limited).... 12
General Electric Co. 6
Gent and Co. ..... —
Johnson and Phillips 1
King, Mendham and Co. ..... —
Laing, Wharton and Down.....2, 13
C. A. Müller 10
United Electrical Engineering Co. 580
Verity (B.) and Sons 6
Western Electric Co. 18
Wood (W.) and Co. ..... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 7

FUSES.
Fowler, Lancaster and Co. 3

GALVANOMETERS.
Nalder Bros. and Co. 16

GAS LIGHTERS (ELECTRIC).
General Electric Co. .....PAGE 6
King, Mendham and Co. ..... —
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 7

GLOBES.
Fowler, Lancaster and Co..... 3

INDIA RUBBER.
D. Moseley and Sons ..... —
Pirelli and Co. 4

INFLUENCE MACHINES.
King, Mendham and Co. ..... —

INSTRUMENTS.
Blakey, Emmott and Co. 2
Latimer Clark, Muirhead & Co. 1
Crompton and Co. (Limited).... 12
Elliott Brothers 17
General Electric Co. 6
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co. ..... —
Nalder Bros. and Co. 16
Sharp and Kent ..... —
Statter and Co. 2
M. Theiler and Sons 3
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 7

INSULATORS.
Joseph Bourne and Son 2
Latimer Clark, Muirhead & Co. 1
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
Price, Sons and Co. ..... —
J. Stiff and Sons 20

IRON ROOFS & BUILDINGS.
Francis Morton & Co. ..... —

IVORY LABELS.
Endolithic Ivory Co. 11

LAMPS.
Anglo-American Brush Co. (Arc and Incandescent)..... 17
Bernstein Electric Co. (Incandescent) 2
Crompton and Co. (Limited).... 12
P. S. Dyer (Edison Incandescent) 2
Edison & Swan United Electric Light Co. (Incandescent) 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
Holmes (J. H.) and Co..... 4
Johnson and Phillips (Arc) .. . 1
Laing, Wharton & Down (Edison & Swan) 2, 13
C. A. Müller 10
Statter and Co. (Arc) 2
Sunbeam Lamp Co. 9
United Electrical Engineering Co. 580
Western Electric Co. (Arc)..... 18
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 7

LIGHTNING CONDUCTORS.
Gent and Co. ..... —
Johnson and Phillips 1
King, Mendham and Co. ..... —
Julius Sax 2

LUBRICANT.
Bell's Asbestos Company 22, 23

MANUFACTURING ELECTRICIANS.
Latimer Clark, Muirhead & Co.. 1
Drake and Gorham ..... —
Electric Apparatus Co..... 2
Elliott Brothers 8
Elwell-Parker (Limited) ..... —
General Electric Co. 6
Gent and Co. ..... —
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1
King, Mendham and Co..... —
Nalder Bros. and Co. 16
Paterson and Cooper..... 2
Julius Sax 2
M. Theiler and Sons 3
United Electrical Engineering Co. 580
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 7

MEDICAL APPARATUS.
General Electric Company..... 6

MEDICAL ELECTRICITY.
Institute of Medical Electricity. 13

METERS (ELECTRICITY).
Chamberlain and Hookham 10

MICA.
F. Wiggins and Sons 13

MOTORS (ELECTRIC).
Anglo-American Brush Co. 17
Elwell-Parker (Limited) 8
Holmes (J. H.) and Co..... 4
M. Immisch..... 18
Shippey Bros. (Limited) ..... —

NON-CONDUCTING COMPOSITION.
Bell's Asbestos Company 22, 23

OIL FILTER.
Woodhouse and Rawson Electric Supply Company of Great Britain (Limited) 7

PAINT.
Indestructible Paint Co. 24

PATENT AGENT. PAGE
J. C. Chapman 6

PLATINA SCRAPS.
Jamieson (W. & J.) 3

PRINTING AND ENGRAVING.
Waterlow and Sons (Limited) .. 10

POROUS CELLS.
Joseph Bourne and Sons 2
Price, Sons and Co. .. .. —
Stiff and Sons 20

PUBLICATIONS.
Alternate Current Transformers 2
Dynamo Electric Machines 15
"Electrical Plant" ..... —
Electricians' Directory 8
Electric Motor and its Applications 15
Handy Shipping Guide 15
London University Matriculation 6
Practical Electricity..... 11
Somali-land, a Month's Sport in 6
Steam Engine Indicator 24

REGULATORS.
Shippey Bros. (Limited)..... —

RESISTANCE COILS.
King, Mendham and Co. ..... —
Nalder Bros. and Co. 16

SALES BY AUCTION 3

SECOHMMETER.
Nalder Bros. and Co. 16

SECONDARY BATTERIES.
Drake and Gorham ..... —
Electrical Power Storage Co..... 19
Elwell-Parker (Limited) 8

SOCKETS.
General Electric Co. 6

SULPHURIC ACID.
Pearce (Wm.) and Sons 16

SUPPLIES FOR CABLE SHIPS
Fritz and Co. 24
F. Lack and Sons 24
Moore (W. and E.) 20
J. S. Starnes and Sons..... 8
Duncan Wallet and Co. 2

SWITCHES.
Crompton and Co. (Limited).... 12
Drake and Gorham ..... —
Edison & Swan United Electric Light Co. 5
Electric Apparatus Co. 2
Fowler, Lancaster and Co..... 3
General Electric Co. 6
Holmes (J. H.) and Co..... 4
Sharp and Kent ..... —
Thompson and Rew ..... —
United Electrical Engineering Co. 580
Wood (W.) and Co. 16
Woodhouse and Rawson Electric Manufacturing Company (Ltd.) 7

TELEGRAPH ENGINEERS.
Latimer Clark, Muirhead & Co.. 1
Elliott Bros. 17
W. T. Henley's Teleg. Works Co. 1
India Rubber & Gutta Percha Co. 12, 16
Johnson and Phillips 1

TELEGRAPH PAPERS.
Waterlow and Sons (Limited) .. 10

TELEPHONES.
W. Blenheim and Co. 16
Fowler, Lancaster and Co..... 3
Gent and Co. ..... —
New Telephone Co..... —
Stanhope Company 13
M. Theiler and Sons 3

TOOLS.
Fenn and Co. ..... —

TRANSFORMERS.
Elwell-Parker (Limited) 8
Sharp and Kent ..... —

TURNERS.
Samuel Elliott 16

VALVE.
Mosses and Mitchell 579

VENTILATING ENGINEERS.
Blackman Ventilating Company. 3

VOLTMETERS.
Nalder Bros. and Co. 16
Sharp and Kent ..... —

VULCANISED FIBRE.
Mosses and Mitchell..... 57

VULCANITE.
Harburg India Rubber Co. .... —
D. Moseley and Sons..... —
North British Rubber Co. 17

WIRE (Covered or Uncovered).
Latimer Clark, Muirhead & Co.. 1
Felten and Guilleaume 1
W. T. Glover and Co. 2
W. T. Henley's Teleg. Works Co. 1
R. Johnson and Nephew..... 2
Johnson and Phillips 1
London Electric Wire Co..... 2
Midland Electric Wire Co. .... —
Phillips Bros. 2
Phosphor Bronze Company 578
Pirelli and Co. 4
W. Rickard ..... —
Western Electric Co. 18

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Firm.	*Telegraphic Address.*	*Telephone.*
Allen (W. H.) & Co.	Pump London	—
Anglo-American Brush Electric Light Corporation	Magneto London	4564
Anglo-American Telegraph Company	—	11028
Balderston and Co.	Balderston Glasgow	—
Barnsley Carbon Co.	Carbon Barnsley	—
Barraclough and Co.	Barraclough, Manchester.	—
Beldam Packing and Rubber Company	Corrugated London	—
Bell's Asbestos Company	Belfry London	4523
Bernstein Electric Lamp Co.	Glolamp London	—
Blackman Ventilating Co.	Ventilator London	—
	Drier Manchester	—
	Blackman Glasgow	—
Blakey, Emmott and Co.	Blakey Emmott Halifax	—
Blenheim (W.) and Co.	Blenheim Egham	—
Booth, Ellson and Co.	Farad Melbourne	—
Bourne (Joseph) and Son	Danesby London	7516
Bumsted (F. D.)	Bags Hednesford	—
Cannington, Shaw and Co.	Cannington St. Helens	11
	Cannington Liverpool	554
Cassell and Company	Caspeg London	39
Chamberlain and Hookham (Limited)	Solar Birmingham	—
Chapman (J. C.)	Powerful London	—
Clark (Latimer) Muirhead and Co.	Regency London	—
Clarke, Chapman, Parsons and Co.	Cyclops Gateshead	—
Crompton and Co. (Limited)	Crompton London	1663
	Crompton Chelmsford	—
Crossley Bros.	Crossley Bros. London	—
	Crossleys Openshaw	—
	Otto Glasgow	—
	Eureka Birmingham	—
	Crossley Bros. Newcastle	—
Davey, Paxman and Co.	Paxman Colchester	—
Direct United States Cable Co.	Direct London	—
	Direct Liverpool	—
Drake and Gorham	Accumulator London	307
Dyer (P. S.)	Dyer Anvers	—
Eastern Telegraph Co. (Station)	Eastern London	1258
Eastern Extension Telegraph Co.	Occidental London	1107
Edison and Swan United Electric Light Co.	Ediswan London	3146
	Ediswan Ponder's End	—
Electric Apparatus Company (Limited)	Campanile London	—
Electrical and Industrial Exhibition	Exhibit Birmingham	—
"Electrical Plant"	Indices London	1533
Electrical Power Storage Co.	Storage London	338
Elliott Brothers	Ohm London	3852
Elliott (S.)	Samuel Elliott Newbury	—
Elwell-Parker Limited	Electric Wolverhampton.	—
Endolithic Ivory Company	Dendron London	—
Facsimile Apparatus Co.	Script London	—
Felten and Guilleaume	Fredennis London	559
	Carlswerk Mulheim Rhine	—
Fowler, Lancaster and Co.	Energy Birmingham	—
General Electric Co.	Electricity London	1887
Gent and Co.	Gents Electricians Leicester	—
Glover (W. T.) and Co.	Phonoscope London	6691
	Walter Glover Salford	1187
Henley's (W. T.) Telegraphic Works Co.	Henleys Works London	1734
Holmes (J. H.) and Co.	Holmes Newcastle-on-Tyne	278
	Vermilionette London	—
Immisch & Co.	Immisch London	7585
India Rubber, Gutta Percha & Telegraph Works Company	Silvergray London	1726
Indo-European Telegraph Co.	Indo London	—
Institute of Medical Electricity	Vigour London	—
Jamieson (W. and J.)	Dental London	—
Johnson and Phillips	Juno London	1010
Johnson (R.) and Nephew	Johnsons Manchester	370
	Johnsons Ambergate	—
	Resistance London	337
King, Mendham and Co.	Kingham Bristol	25
Kirkaldy (J.) and Son	Kirkaldy London	—
Laing, Wharton and Down	Whardown London	3602
London Electric Wire Co.	Electric London	105
Manchester Electric Works Co.	Induction Manchester	—
Marshall, Sons and Co.	Marshalls Gainsboro'	—
	Engine London	6648
Moore (W. and E.)	Employment London	—
Morton (Francis) and Co.	Dropper London	—
	Ironsides Liverpool	624
Moseley (D.) and Sons	Moseleys London	353
	Moseleys Manchester	—
Mosses and Mitchell	Insulator London	—
Nalder Bros. and Co.	NalderWestminster London	3120
New Telephone Co.	Phonic London	—
North British Rubber Company	Weba Edinburgh	—
	Weba Glasgow	—
	Weba Liverpool	—
	Weba Manchester	—
	Ebwa London	370
Paterson and Cooper	Patella London	1140
Phillips Bros.	Flexible London	5422
Phosphor Bronze Company	Phosphor Bronze London	4557
	Phosphor Birmingham	—
	Phosphor Liverpool	—
Pirelli and Co.	Società Pirelli Milano	—
Price, Sons and Co.	Price Bristol	(7279 6620
Priestman Brothers	Priestman Hull	—
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	Anglia London	—
Richards (Geo.) and Co.	Richards Altrincham	—
	Herodes London	—
Sanitas Co.	Sanitas London	1011
Sax (Julius)	Sax London	3848
Schmidt-Douglas Electric Company	Dynamo Bradford	—
Schuckert (C. A. Muller)	Schuckert Nürnberg	—
Sharp and Kent	Megavolt London	3125
Shippey Bros. (Limited)	Shippey Brothers London	—
Stanhope Company	Stanhope London	1591
Starnes (J. S.) and Sons	Starnes Ratcliffe London	—
Statter (J. G.) and Co.	Statter West Drayton	—
Stiff (J.) and Sons	Stiff London	4627
Sunbeam Lamp Co.	Sunbeam Gateshead	—
	Cyclops London	4251
The Electrician	—	2714
United Electrical Engineering Co.	Jablochkoff London	—
Verity (B.) and Sons	Electroler London	2643
Wagener and Co.	Wagener Altena	—
Wallet (Duncan) and Co.	Dunwallet London	418
Waterlow and Sons (Limited)	Waterlows London - wall	—
	London	—
Western Electric Co.	Relay London	—
	Electric Chicago	—
	Microphone New York	—
Wheatley Kirk, Price and Goulty	Indices London	1533
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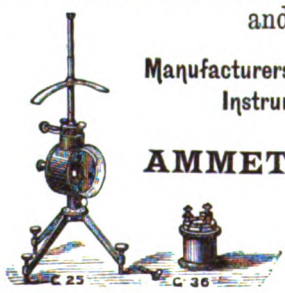

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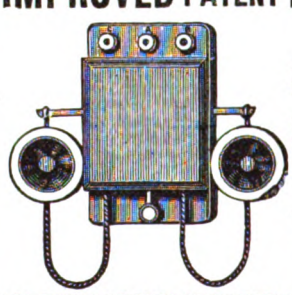

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ing Acts. But as these applications have been made either with direct reference to the wishes of the respective Vestries or in opposition to them, we may take it that Major MARINDIN will have before him the subject as a whole, including, not improbably, the views of the newly-created County Council, who will have assumed the functions of the Metropolitan Board of Works, and inherited the right to be consulted in respect of the open spaces previously under the jurisdiction of that body.

The inquiry does not promise to be a very brief or a very agreeable one if, as may be surmised, the Vestries insist strongly upon their own preconceived views. In reality, the chief complications of the situation seem to be due to the over-zeal and activity of the Vestries. But besides this, the fact that for a comparatively limited area of the Metropolis already eight electric supply companies are applying for eleven Provisional Orders, covering no fewer than twenty-three "local authorities," as defined by the Act, adds considerably to the difficulties to be overcome, especially if the remaining Vestries are as self-assertive as those who have already spoken their minds on the subject. We noted at the time in our comments on the Kensington scheme that the six companies affected had shown a much too pliant temper in yielding to the suggestions of the Vestry as to the reduction of the forty-two years' interval allowed by the Act, and we have reason to believe that this opinion is shared to some extent by the Board of Trade. The Companies will now have an unlooked-for opportunity of retrieving the error then committed, and we trust that they will be wise enough to present a bold and united front to the attack which is sure to be delivered upon this point. So long as they hold to the terms granted by the Act their position is legally and logically unassailable, and to tamely yield evinces a moral cowardice, which is the more reprehensible since the consequences will inevitably be felt by Electricity Supply Companies in all parts of the country.

Another important point which the present inquiry will have to determine is the feasibility of splitting up the areas represented by the parish unit into several sections served by as many competing electric light supply companies. In Kensington—and its example has been partially followed elsewhere—the Vestry appear to have acted on the principle that, as there were so many applicants exactly so many districts should be assigned to them. In some other areas the local authority has shown a more independent desire to place them each under one single and well-appointed company; whilst others, again, prefer to allow an indiscriminate competition over the whole area, without any strictly defined topographical boundaries. To reconcile these various and conflicting propositions will be one of the chief tasks of the Board of Trade inquiry; and we need hardly say that it is one of no small magnitude and complexity. Moreover, as the various Metropolitan areas have been taken up, or, more correctly, applied for, the impracticability of the sub-division which the companies agreed to has become almost self-evident. Looking at the Map of Metropolitan Improvements issued with the private Bills this Session, it will be seen that the electric lighting areas are severally laid claim to by a number of companies varying from two to six, and with absolutely no relation whatever to the districts they may occupy in adjacent or remote quarters. Manifestly such a sub-division of their operations is the least economical that could be devised for the companies. If any one of the areas were to be exploited alone, and by way of an experimental competition between half-a-dozen of the leading supply companies, the thing might be tolerated, yet even then only as an experiment and scarcely as a serious business enterprise. But directly operations are contemplated beyond this narrow boundary the whole system assumes the character of a series of independent schemes, that company alone being in any degree fortunate which by a lucky chance happens to obtain two districts immediately adjoining although in different parishes.

At the present stage of electric lighting business it would be impossible, and even if possible undesirable, that any very large area at all resembling those supplied by the London gas corporations should be assigned to one electric supply company. A combination, resulting in a similar way, will doubtless take place in due course as it has in the case of the gas companies; but for the present it would be unwise to attempt too much; and the Board of Trade will take good care, in the interests of the public, that a judicious limitation of the several companies' operations is not overstepped. If, however, any one company is deemed capable of supplying more than one small area in different localities, that company may surely be trusted to supply any one given area of equal dimensions in one locality. We shall not be surprised, therefore, if the Board of Trade were to set aside the propositions now before it so far as the majority of the Vestries are concerned, and adopt some intelligible sub-division of its own on a more rational basis, giving to each company a certain local area for which it shall be solely responsible, though not necessarily confined to that one area. When the company is large and sufficiently equipped with capital and experience there is no reason why it may not have two or more important areas assigned to it. All that we deprecate is the excessive sub-division of small parishes and the splitting-up of the resources of the companies into a multitude of insignificant and separated undertakings.

As to the other objections raised in our former article on this subject, we need not refer to them again further than to observe that this inquiry will afford opportunity for laying them before the Board if the companies concerned think it worth their while to do so.

THE INDIAN TELEGRAPH DEPARTMENT.

(From the *Indian Engineer.*)

The annual report of the Indian Telegraph Department during 1887-88 shows that a considerable increase took place during that year in the number of miles of line open, the number of messages sent, and in the receipts. The most important event during the year was the transfer to the charge of the Director-General of the Indian Telegraph Department of the Indo-European Telegraph Department, which had hitherto been administered by a Director-in-Chief, whose headquarters were in London. This transfer took place on the 15th February, 1888. Although the total number of messages received for despatch by the Indo-European lines increased by nearly 30,000 during the year, and the total receipts by about 1½ lakhs, it is stated that the traffic between India and Europe shows no marked difference between that of the past three years, the increase being due to a greater number of messages passing between Europe and countries to the east of India, including Australia. The Teheran route was interrupted with Great Britain from the 13th to the 17th December, 1887, and from the 1st February, 1888, to the end of March, owing to the failure of the North Sea cables between Emden and Lowestoft, and owing to this cause and the delay in repairing the second interruption due to bad weather the traffic by this route shows a considerable falling off, while the Suez route proportionately gained. There seems to have been no break in the Suez route which is said to have worked admirably, and the only important interruption on the Turkish route was one between Bagdad and Mossul in April, 1887, which lasted 16 days.

With regard to telegraphic communication with other Eastern countries, communication was maintained throughout the year, without interruption, between India and The Straits, China, and Australia, though direct communication between India and China was cut off between the 30th July and the 7th August by the failure of the single cable which connects Singapore and Saigon. During this interval the China traffic from and to Europe was sent by the Great Northern Telegraph Company's line through Asiatic Russia. The Indo-Siam line is said to have proved almost valueless as a through international route from India to Saigon, and the number of messages sent was very small. The Northern route from Moulmein to Bangkôk, *via* Raheng, was almost constantly interrupted

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throughout the year, and the Southern route *via* Mejetta and Kanburi was also subject to long interruptions, mostly in Siamese territory. The portions of these lines within British territory, though traversing most difficult and unhealthy forest and mountainous country, were kept in good working order. Representations regarding the state of the line in Siamese territory were made to the Siam Government, and it is hoped that some improvement will take place.

Telegraphic communication in China was considerably extended during the year. The Northern line from Shanghai *via* the provinces of Hupe and Szechuen was completed to Yunnan and three offices were opened in that province, which is partly co-terminous with the British frontier in Upper Burma. A second line from Yunnan to the coast ports, *via* the provinces of Kwangsi and Kwantung to Canton, was also under construction, and from recent official reports was expected to have been completed to Yunnan in March last, thus affording two routes from that place to the Pacific Ocean. There now remains but a short link to connect the wires of the Indian Telegraph Department and those of the Chinese Government, in the neighbourhood of Bhamo, and when this is done, it is probable that a comparatively cheap tariff for telegraphic communication between India and China will be arranged for between the Governments of the two countries. At the present time the distance between the nearest points of the Indian and Chinese systems is only about 140 miles, viz., from Bhamo to Momein, in Western Yunnan.

During the year the Island of Formosa was connected with Foochow by a submarine cable, and three offices were opened in the island; telegraphic communication was established between Malacca and the States of Selangor and Sungie Ujong, and three offices opened in each State. A cable was also laid from Gibraltar to Tangier, establishing communication with Morocco.

The total length of line open at the end of the year was 93,743 miles, representing 93,517 miles of wire and 226 miles of cable. During the year there was an increase in the total length of 6,657 miles, representing 6,627 miles of wire and 30 miles of cable. A large portion of the wire lines are worked by railway companies, there being no less than 33,043 miles of wire in connection with the various railway systems, and much of the increase in the total length of line noticed above was caused by the opening up of new lines or the extension of existing ones. In Burma the work has mainly consisted in consolidating and strengthening existing lines. Communication between Upper Burma and Assam has been established by the completion of the line from Manipur *viâ* Tammu and the Chindwin Valley. This line runs from Mandalay to Ava, where a cable crosses the Irrawadi and connects it with Sagain. From thence it is carried across country *via* Myinmu to Moniwa where it meets the Chindwin and follows the Valley up to the junction of the Yu River, after which it follows that river to Tammu. The connection of Upper Burma with India by this route has been attended with considerable difficulty, and the staff employed suffered much from hardship and exposure which brought on fever and malaria.

The result of the trial of hard drawn copper wire having been favourable, a wire of this metal was put up between Bombay and Madras, 800 miles, and between Bombay and Nagpur, 520 miles. It is in contemplation to extend this latter by wire of a similar metal, to Calcutta, as soon as the line of post along the Bengal-Nagpur Railway is completed. The results obtained on the new wire are highly satisfactory. Bombay and Madras are now able to work quadruplex without any intermediate translating station. The difficulties connected with the manipulation and erection of the "hard drawn copper wire" have in practice proved, with ordinary precautions, to be less than was anticipated. The use of this wire would have been much extended had it not been for an exceptional rise in the price of copper, which has rendered the purchase of it for the present almost prohibitive. It is, however, in contemplation to attempt its manufacture in the telegraph workshops in Calcutta, utilising old cable core and copper in stock.

Quadruplex working was introduced during the year on the line between Calcutta and Rangoon, a distance of over 1,000 miles, with Akyab as a half-way station, where the signals are automatically repeated. The introduction of the same system was also arranged for on one of the wires between Calcutta and Agra, with Allahabad as the repetition station. The number of circuits worked duplex has also increased, and there are now twenty-three main circuits, most of them of great length, worked on the quadruplex or duplex system. The suspension of a copper wire between Madras and Bombay, which was completed early in the year 1888, has very much improved quadruplex working between those cities, and the important Australian and China traffic which mainly traverses India by this route is disposed of with great ease and rapidity.

With a view to afford the Meteorological Department facilities for promptly warning the various ports of India and Burma of approaching bad weather a special class of storm signal telegrams was introduced with the approval of Government on the application of the meteorological reporter to the Government of India. A considerable number of the meteorological observers throughout India are *employés* of the Telegraph Department, and as the work of the two departments are so much connected, the arrangement is advantageous, and saves much delay in the despatch of weather telegrams.

ARC LAMPS AND THEIR MECHANISM.

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(Continued from page 537.)

[A.] Driving Power.

The following devices have been used:—

1. *Gravity.*—Descent by its own weight of upper carbon holder [innumerable lamps]; ditto, aided by weights specially attached [Gülcher, 1915[82]]; ditto, partially opposed by coiled spring to compensate for consumption [Siemens, 366[88]]; clockwork driven by weights [Staite, 11783[47]]; lower carbon floated upward in mercury [Tommasi, 4405[79]].

2. *Coiled Spring.*—Drives by pinion and rack, or pulley and cord [Foucault, 1848; Staite, 11449[46]]. Differential action of two coiled springs [Foucault-Duboscq lamp].

3. *Electro-magnetic Motor.*—(*a*) Suction of core by solenoid; (*b*) electric motor rotates and drives carbon rod [Bousfield, 523[79]; Breguet, &c.]; (*c*) electro-magnetic vibrator drives carbon rod [Clark-Bowman, 1182[83]; Newton, 1623[83]; Pieper, 4133[86]; Holmes, 769[86]].

4. *Hot Air.*—Heated air rising from lamp drives fan to propel carbons [Varley, 5656[81]].

[B.] Striking Mechanism.

To strike the arc requires mechanical devices; but as these are to be actuated by the current itself, it is appropriate first to consider what electric mechanism is necessary or sufficient to actuate the movement. Assuming that the carbons are initially in contact when there is no current, the current when turned on must part them; the appropriate device is therefore an electromagnet (or solenoid with its core in lieu thereof) having its coils in the main circuit of the lamp. [Foucault, 1847; Staite, 11783[47], and in the vast majority of modern lamps.] If, however, the carbons are initially apart, the lamp must itself bring them together, and the appropriate device to actuate this movement will be an electromagnet (or solenoid) connected as a shunt, and therefore having fine wire coils of high resistance. Such an arrangement will bring the carbons together by the action of the by-pass current, and as this falls almost to zero on the contact of the carbons, they will be at once parted (and the arc struck) by the opposing force: this force may be that of gravity [Lontin, 1875) or a spring [Lever, 2092[82]; Thomson-Rice]. The disadvantage of this second method is that the initial resistance of the whole series of lamps standing with their carbons parted is enormous unless there is a cut-out circuit. Another method of striking the arc is by cutting out a main-circuit electro-magnet [Crompton, 346[82]; Bright, 377[82]].

The modes of parting the carbons are various:—

1. Drawing both carbons asunder by gearing [Foucault-Duboscq lamp].

2. Drawing down the lower carbon by electro-magnet placed in base [Staite, 11783[47]; Serrin, Breguet, Sellon, Newton, Pieper, Holmes, &c.], or by electro-magnet situated at top [Crompton "E," 1881; Gramme; Silvertown Co.; Fein, 1888].

3. Lifting upper carbon rod [Roberts, 14198[52]; Slater and Watson, 212[52]; and the vast majority of modern lamps, Brush, Siemens, Crompton, Pilsen, Brockie-Pell, Thomson-Houston, &c.], or lifting upper carbon by an electro-magnet situated in the carbon rod [Abdank, 1884]; or by lifting bodily the upper carbon and the whole of the feeding train [Crompton, 346[82]; Fyfe and Main, 3821[81]; Bergot, Wood, Hochhausen, Maxim, 1649[80]; Gümpel, 253[81], &c.]; or by rocking the feeding train around a centre [Brockie, 2370[82]; De Puydt].

The mechanical devices for performing these various actions are numerous, and their action is complicated by the endeavour of many inventors to cause the same mechanism which initially strikes the arc also subserve the purpose of feeding the carbons. In some lamps, however, these functions are kept separate. An example of a lamp in which the striking and feeding mechanisms are kept separate is afforded by the Breguet lamp (Fig. 3), in which an electromagnet draws down the lower carbon holder to strike the arc, whilst the feeding is accomplished in the subsequent gradual descent of the upper carbon. In the lamps of Newton, Sellon, and Holmes, there is used the special form of short-range electro-magnet, *a* (2 in the list), having a central core and external tube of iron. There is a

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very numerous class of lamps in which a clutch is caused to grip the upper carbon holder, and then to raise it so as to strike the arc; the same clutch being subsequently so operated as to permit the carbon holder—a smooth rod—to slide down by degrees as required, to feed the carbon pencil forward. Such devices are best considered under the heading of feeding mechanisms.

The adjustments of the striking mechanism may be of two kinds—(1) adjustments of range, such as limiting stops and set screws; (2) adjustments of force such as the regulable spring shown in Fig. 1 at the bottom.

The main-circuit electro-magnetics and solenoids, used for striking the arc, are wound with a wire of large enough section to carry the required current without undue heating, and are of small resistance. The weight of copper wire employed varies from one to four pounds; and the resistance varies from 0·05 to 9·2 ohms.

[C.] Feeding Mechanism.

The electric devices here differ in the case of lamps for parallel working and lamps for series working.

(1.) *For Lamps in Parallel.*—Assuming that the supply mains are kept at constant potential, then the lamp mechanism must be responsible for keeping the other factor of the electric power, namely, the current through the lamp, at a constant value. That is, say, whenever by reason of the burning away of the carbon points the arc grows long, offering more resistance, and, therefore, reducing the current below its normal value, the lamp must automatically feed the pencils forward, and so readjust the current. It is obvious that, in this case, the weakening of the current through the lamp may be caused to bring the feeding mechanism into operation by the use of an electromagnet (or solenoid) in the main

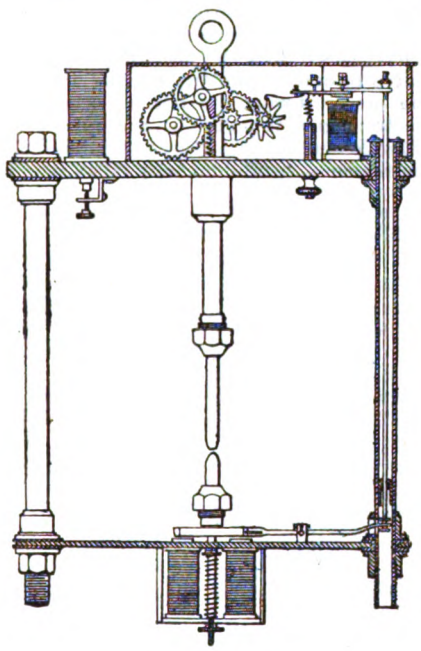

Fig. 3.—Breguet Lamp.

circuit. For if the armature of this electromagnet be held back by a spring or weight which only just counterbalances the pull of the magnet when the current is normal, the weakening the current will at once cause a movement of the armature which may be utilised to relax a clutch, lift a detent, or release an escapement. And it is also obvious that in this case it is possible to arrange the same electromagnet which strikes the arc to actuate the feed. Examples of the use of a single main-circuit electromagnet to actuate both the striking and the feeding mechanisms are to be found in the Serrin lamp, in the Gülcher lamp, and in the Brush lamp as arranged for parallel working.

(2.) *For Lamps in Series.*—Assuming that the dynamo is doing its duty, and keeping the current constant, then in this case the lamp mechanism must be responsible solely for keeping constant the potential between the terminals. Whenever by reason of the burning away of the carbons the arc lengthens and offers more resistance, if the same current is still supplied to it and forced through this greater resistance it will burn more brightly, and the difference of potentials between the terminals of the lamp will rise above its normal value. The lamp must then automatically bring its carbons nearer, and readjust the potentials to the proper number of volts. It is obvious that the appropriate device to actuate the feeding mechanism must, in this case, be something that can play the part of a voltmeter; and will actuate the mechanism when the volts rise above their normal value. Practical voltmeters are of two kinds; (*i*) those which depend on the magnetic effects of the current that will flow through a wire of high resistance placed as a shunt across the two points between which the differences of potential exists, and (*ii*) those which depend on the heating effects of the current in such a wire. Either of these effects may be used to control the feeding mechanism of arc lamps; that is to say, the feed must be controlled by a shunt circuit, which will actuate the mechanism as soon as the potential rises above its normal value. The usual device is an electro-magnet (or solenoid) of fine wire, and of high resistance (from 200 to 450 ohms), the armature of which is counterbalanced by the force of a spring, or by gravity, or by an opposing main circuit electro-magnet (or solenoid). An alternative device, not, however, in general use, is a long thin platinum wire, which when heated by a current above the normal value will expand and actuate the feed. Thermal expansion has been attempted as a method of regulation by several inventors. [Lontin 2074[77]; Siemens, 2281[78] and 2110[79]; Munro, 1626[82]; Edison, 2072[82]; Pollak, 1888, &c.]

In the following table are comprised the several electrical arrangements for controlling the feeding mechanism:—

(1.) *Constant Potential Lamps (for Parallel Working).*—(*a*) Series electro-magnet, same as used for striking (Serrin, Gülcher, Brush, Crompton, &c.). (*b*) Series electro-magnet, separate from the striking electro-magnet (Fontaine). (*c*) Differential arrangement. Series winding partly opposed in shunt winding, on separate cores or parts of mechanism (Lacassagne and Thiers, 2456[56]; Siemens, Brockie-Pell). (*d*) Ditto, but wound on same cores.

(2.) *Constant Current Lamps (for Series Working).*—(*a*) Shunt electro-magnet alone, acting against gravity or spring (Lontin, 1877; Lever). (*b*) Shunt electro-magnet separate from the striking (series) electro-magnet (numerous lamps: Breguet (Fig. 1), Crompton "E," Sellon, Gramme, Pieper). (*c*) Differential arrangement: Shunt winding pulling against series winding on separate part of mechanism. (Lacassagne and Thiers, Siemens "differential," Pilsen, Crompton-Crabb "DD," Thomson-Houston, Brockie-Pell, Kennedy.) (*d*) Differential winding: (Numerous lamps, Brush, Weston, "Simplex.")

The typical arrangement of circuits for lamps that are to be run on a system of arc lighting in series is shown in a generalised diagram in Fig. 4. The striking coil is in the main circuit; the feeding

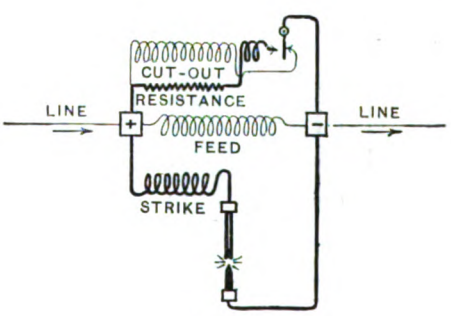

Fig. 4.

coil is a shunt, which if wound on the same series coil in any of the differential systems must be so wound that the currents circulate in opposing senses. There is also added a cut-out circuit, having both a shunt coil and a small series coil; but these must be so wound as to help one another's magnetic power, and the small series coil must itself be a shunt to the main circuit of the lamp.

We are now prepared to enter upon the mechanical devices which have been suggested for the feeding-mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake, by the electro-magnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon rod to drive the train; but the rack lamps differ greatly amongst themselves. Again, there is another class of lamps in which the upper carbon rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electro-magnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

Feed Motions.

(1.) *Rack and Train controlled by*—(*a*) Star wheel and detent (Staite, 18783[47]; Foucault-Duboscq; Serrin, 653[58]. (*b*) Fly and detent (Staite, 1848; Duboscq, 1855). (*c*) Brake-wheel and brake (Chapman, 739[55]; Crompton, 346[82]). (*d*) Escapement with pedulum or balance and detent

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(Siemens, 4949[78]; Harding, 3166[81]; Waterhouse, 5185[81]). (*e*) Escapement and paddle (Waterhouse, 5185[81]). (*f*) Governor with detent or moderator (Waterhouse, 5185[81]). (*g*) Magnetic brake-wheel or detent (Brockie, 1713[82]; Harling, 3473[81]). (*h*) Liquid brake (Hopkinson, 153[81]).

(2.) *Clutch or Clamp on Rod.*—(*a*) Tilting ring, tilting eyelet, &c. (Slater and Watson, 212[82]; Brush, 2003[78]; Lumley, 1249[82]; Lever, 2092[82]; Thomson-Houston; Waterhouse, &c.) (*b*) Split cone gripped by fork (Slater and Watson, 212[82]). (*c*) Split nozzle forced into cone mouthpiece (Bürgin, 4820[81]). (*d*) Split tube held together by oblique levers (Rogers, 3236[82]). (*e*) Gripping springs at side (Lever, 3599[81]; Munro, 1626[82]). (*f*) Gripping fingers (Roberts, 14198[82]; Joel, 5157[79]; "devil's claws," Harding, 3166[81]). (*g*) Washer jambed by ball bearing (Young, 1689[82]; or roller, Newton, 4559[81]). (*h*) Tilting clamp or nipping clamp (Common, 626[82]). (*j*) Nipping lever (Grimstone, 1670[81]; Mondos, 5490[81]). (*k*) Scissors lever (Joel, 3970[84]; Jarman, 563[82]; Gerard-Lescuyer, 2992[82]). (*l*) Spiral spring surrounding rod (Keilhotz, 1886; Thouvenot, 1887). (*m*) Forward-pointing springs (lobster-trap) (Newton, 1623[83]; Clark-Bowman, 1182[83]; Holmes, 769[86]; Hawkes, 157[82]).

(3.) *Clutch-wheel or Brake-wheel.*—(*a*) Nipping lever outside brake-wheel (Gramme, 1861; Common and Joel, 1040[81]; Brockie, 4419[82]). (*b*) Nipping lever inside rim of wheel (Union Company, 392[82]; Brockie, 4419[82]). (*c*) Elastic band brake (Statter, 2985[83]). (*d*) Elastic internal ring brake (Siemens, 6957[87]; Fein, 1888). (*e*) Wheel lifted against brake or detent (Bürgin, 4820[81]). (*f*) Brake-wheel lifted upon brake-lever (Gümpel, 253[81]; Crompton-Crabb, 2539[83]). (*g*) Friction-pad on rim of wheel (Abdank, 1882).

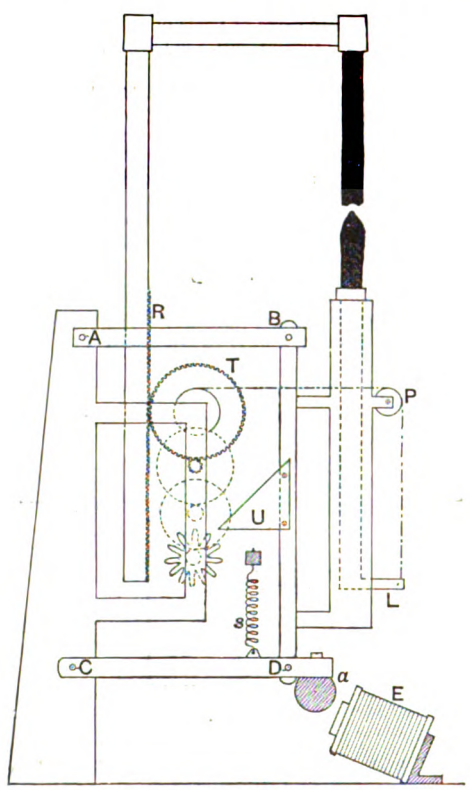

FIG. 5.—Serrin's Lamp.

(4.) *Screw Motion.*—(*a*) Screw worked by weight of upper rod (Hopkinson and Muirhead, 153[81]; Cance, 3976[81]; Akester, 2419[82]). (*b*) Screw worked by motor (Tchikoleff, 1874). (*c*) Screw worked by step-feed (Street-Maquaire, 9666[85]). (*d*) Screw worked by vibrated wheel (Siemens, 6987[87]).

(5.) *Cord and Pulley Motions.*—(*a*) Cord and pulley to core of solenoid (Archereau, 1848; Jaspar, 83[79]). (*b*) Cord and pulley connecting carbons, with long-travel solenoid (Pilsen lamp, 1397[80]; Doubrava, 1033[86]). (*c*) Cord gripped by controlling cam (Harding, 4590[79]). (*d*) Cord and pulley for differential feed (Weston, 1883; Kennedy, 1888).

(6.) *Step-by-Step Motions.*—(*a*) Step detent worked by electro-magnet (Deleuil, 1856; Brockie, 898[82]; Gatehouse and Kempe, 2569[82]; Kennedy, 5524[81]).

(7.) *Magnetic Clamps and Clutches.*—(*a*) Tilting magnet clutch on rod (Roberts, 14198[82]; Gulcher, 2038[81]). (*b*) Magnetic clamp on brake-wheel (Harling and Hartman, 3473[81]; Hardt, 1886).

(8.) *Electric Motor Action.*—(*a*) Motor screws carbon up or down (Tchikoleff, 1874, and 2198[81]; Maquaire, 1889). (*b*) Winds up with cord or rack (Andrews, 2321[79]; André, 2764[80]; Bousfield, 523[79]; Brequet, 1879). (*c*) Motor itself controlled by shunt magnet (Thomson-Houston, 315[80]). (*d*) Motor with copper damper (Thury, 1888).

(9.) *Hydrostatic and Pneumatic Action.*—(*a*) Carbons controlled by admission of liquid or gas (Lacassagne and Thiers, 2456[56]; Hopkinson, 3509[80]; Leibold, 1886; Sedlaczek, 1883).

(10.) *Vibrating Feeds.*—(*a*) Make-and-break lever vibrate forward-pointing springs (Newton, 1623[83]; Pieper, 4647[86]; Holmes, 769[86]). (*b*) Make-and-break lever actuates escapement (Harding, 3166[81]). (*c* Make-and-break lever actuates detent on train (Gramme, 1880). (*d*) Make-and-break lever hammers rod through clutch (Letang, 5509[87]). (*e*) Make-and-break lever works internal clutch-wheel feed (Fein, 1888). (*f*) Make-and-break lever drives pallet and screw feed (Siemens (Alteneck), 1885).

(11.) *Periodic Feeds.*—(*a*) Periodic drop of upper carbon and lift through definite range (Brockie, 898[82] and 1713[82]). (*b*) Periodic currents to magnet sent through second wire (André, 4948[81]).

(12.) *Continuous Feeds.*—(*a*) Clockwork step feed, length of stroke varied by magnet (Brockie, 898[82]). (*b*) Pendulum or governor, having rate varied by magnet (Waterhouse, 5185[81]). (*c*) Rack-train controlled by magnetic retardation on copper wheel (Niaudet, 1878).

(13.) *Hammering Feeds.*—(*a*) Rod driven through clutch by vibrating hammer (Letang, 5509[87]; Capito and Hardt, 1887). (*b*) Ditto, by tilting lever (Jolin, 3570[83]). (*c*) Ditto, by magnetic pile driver on rod (King, 1888).

Outside the classification adopted above are several well-marked features of mechanism; one of these is the *parallelogram motion*. A typical case of this is afforded by the well-known Serrin (653[59]) lamp (Fig. 5). A jointed parallelogram is constituted by the pieces which meet A, B, C, D. The side A C, is fixed, being part of the frame, whilst the levers A, B, C, D, rise and fall through a small angle, carrying with them the upright B D. To this upright is fastened a sleeve, through which the lower carbon holder passes. This moving parallelogram is held up by a spring, *s*. When the electromagnet E (in main circuit) attracts its armature, *a*, the parallelogram, and with it the lower carbon, sinks, and so the arc is struck. At the same instant a projecting triangular detent, U, engages against the star wheel of the driven train and locks it, so that the upper carbon cannot descend. As the carbons are consumed the current is weakened, owing to the increasing resistance of the lengthening arc, and the electromagnet lessens its attraction; consequently the parallelogram gradually rises, until a moment occurs when the detent ceases to lock the star-wheel. The upper carbon-holder is now free to descend a little, driving the train of wheels, shortening the arc, restoring the normal current, and so again causing the electromagnet to pull down the parallelogram and lock the wheels. Parallelogram motions are to be found also in Bürgin's (4820[81]), and in Siemens' pendulum lamp (4949[78]).

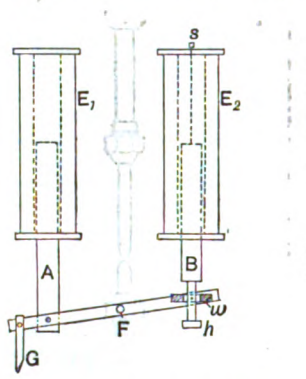

FIG. 6.—See-saw or Brockie-Pell Lamp.

Another characteristic mechanism is the *see-saw* lever. Fig. 6 shows the form used in the Brockie-Pell lamp (12681[85]). The earliest use of the see-saw, attracted at opposite ends by series and shunt magnets respectively, occurs in the lamp of Lacassagne and Thiers (2456[56]); whilst modern examples are Weston's lamp, the Thomson-Houston lamp (Fig. 14), and Fein's lamp of 1883. [Also Moffat and Chichester, 3441[81]; and Chadburn, 2755[81], where the see-saw works a clutch]. A compact modification of the see-saw mechanism occurs in one form of Weston's lamp, and again in Kennedy's lamp of 1888, Fig. 10. Here the lever is replaced by a pulley over which passes a cord or ribbon of metal. In this lamp the shunt solenoid is furnished with a plunger core, whilst the series solenoid on the left has a plunger and an external iron mantle to increase its power. The smaller pulley communicates the motion to a clutch. The advantage of the see-saw, and of its pulley equivalent, is that such an arrangement enables the lamp to be used as either a constant potential lamp or as a constant current lamp. In the former case the shunt coil holds up its end, whilst the see-saw is operated by the variations of the current in the series coil. In the latter case the actions are the inverse of this.

The *rack-train* mechanism which forms the first-class in the preceding list, presents two special points. As this mechanism is in itself non-retractile, and can only propel the carbons forward, it cannot be used with non-homogeneous carbons of second quality, unless special provision is made in the striking mechanism of the lamp for a retractile movement. There is nothing retractile, for example, about the Breguet lamp (Fig. 3), but there is about the Serrin (Fig, 5), for the lower carbon holder, which descends

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to strike the arc) is never held tight down by the electro-magnet, but takes up a position of equilibrium. The other point is that in these rack-train lamps some device is requisite to lock the train at the instant of striking, otherwise the feed motion would neutralise the strike motion. In some lamps (Breguet, Sellon, &c.), there is a mechanical connection from the striking part to lock the feed. In some other lamps the action is performed electrically. In the De Puydt lamp a pin on the train frame engages with a forked connecting piece from the feeding lever.

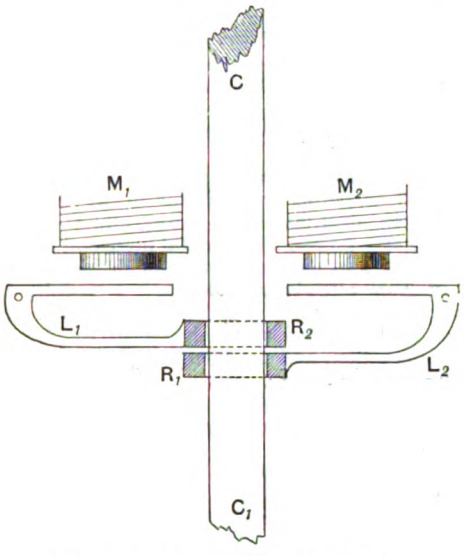

FIG. 7.—Slater and Watson's Clutch.

A characteristic arrangement, applicable to rack-train lamps, is that in which, for the purpose of striking the arc, the whole train mounted in its framework, together with the rack and the upper carbon rod, is bodily lifted by the use of an electro-magnet in the main circuit. (Crompton, 346[82]); Fyfe and Main, Hochhausen, Gümpel, Berjot, Wood, Maxim, &c.) More neat is the method of rocking the train bodily around the axis of one of the wheels of the train (Brockie, 2370[82]; and De Puydt).

Passing from the *rack-train* lamps to the *clutch* lamps, it may be noted how much ingenuity has been expended in attempting to find a form of clutch which will prove reliable under all conditions of working. Two of the very earliest forms of clutch mechanism are worth recalling in this connection. These are both due to Slater and Watson (212[52]). The first (Fig. 7) shows a carbon rod sliding through a couple of rings or eyelets, which are tilted by the attraction of an electro-magnet to grip and raise the rod. In the second (Fig. 8) the clutch consists of a split conical washer, the two halves

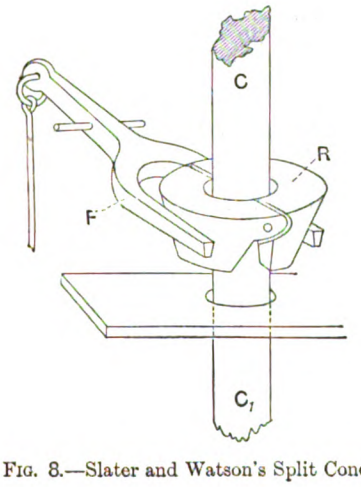

FIG. 8.—Slater and Watson's Split Cone.

of which are hinged together. These are compressed by the rising of a fork, which nips and raises them. The tilting ring introduced by Brush is too well known to need comment. Lever's modification of the tilting ring is shown in Fig. 9, the rim below the ring causing the thrust to act more obliquely at first, and allowing the clutch to work even when the aperture is considerably worn. In the latest forms of this clutch the ring has a tail-piece which is hinged to the frame of the lamp. Another successful form of tilting clutch is shown in Fig. 10, which represents the mechanism of Kennedy's lamp. The clutch has a long tail, provided with an adjusting screw to regulate its position, and bears against the carbon-rod by a slender spring, *s*, above. It is worked by a thin cord, *d*, running over a pulley in connection with a differential arrangement of shunt, S, and series, M, solenoids described above.

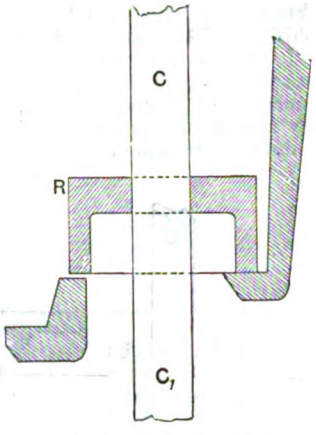

FIG. 9.—Lever's Clutch.

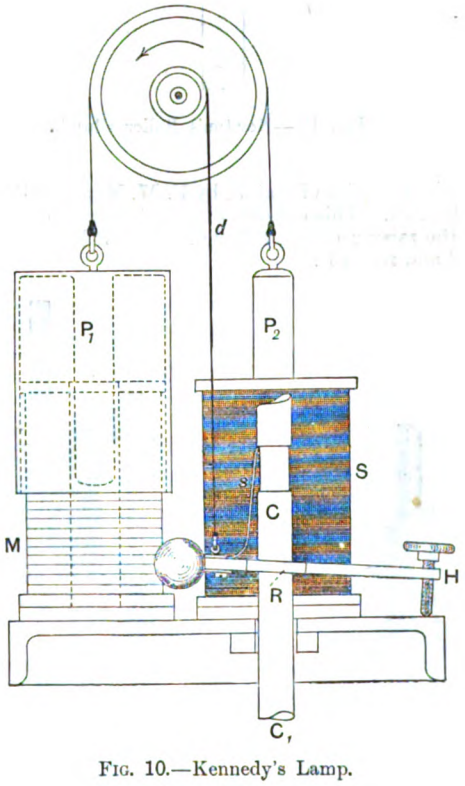

FIG. 10.—Kennedy's Lamp.

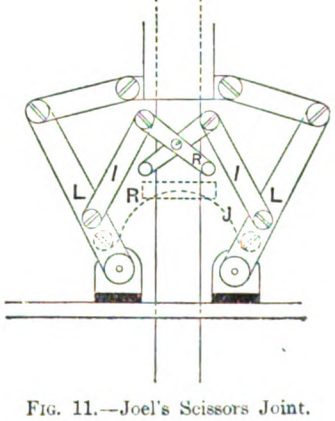

FIG. 11.—Joel's Scissors Joint.

A clutch provided with a spring that bears against the carbon rod is also found in the Clarke-Bowman lamp (1182[83]), the feeding in this case being accomplished whilst the clutch is held up, by giving to it a mechanical vibration. In the Kennedy lamp the spring on

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the clutch also serves the purpose of finally arresting the descent of the carbon holder, catching on a groove cut around its upper end when the carbon pencil is all consumed. Another simple clutch with spring mounting, worked by the mutual repulsion between two similarly magnetised cores, has been devised by Swinburne (11893[86]).

Clutches of the knee-lever type have been devised by Lorrain (183[83]) and Joel (3970[84]). The more complex "scissors joint" levers, used in one of Joel's lamps, are drawn in Fig. 11. Their action is obvious, as their upper end is raised by the upward pull of the electro-magnet or solenoid they grip, and raise the carbon rod, and they relax their grip on being lowered to feed the arc. Very similar devices are found in Gerard's and Jarman's lamps.

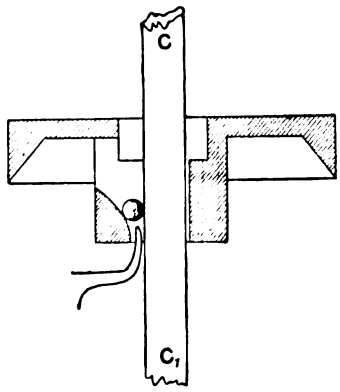

FIG. 12.—Newton's Roller Clutch.

An ingenious species of clutch, by F. M. Newton (4559[81]), is illustrated in Fig. 12. This consists of a ball-bearing or roller-bearing, which on the raising of the collar in which it lies jams against the carbon rod and raises it.

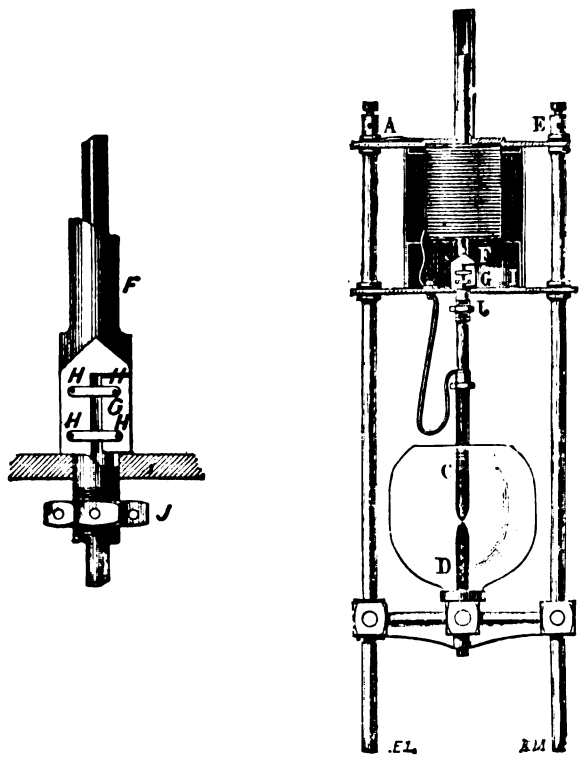

FIG. 13.—Rogers' Clutch.

Another extremely simple clutch (Lorrain, 639[83]), consists of a plunger working horizontally through a solenoid, pressed sideways by a spiral spring against the carbon rod; the pressure of this is taken off, when feeding is required, by the pull due to the current in the solenoid, which is connected as a shunt. Rogers' (3236[82]) simple and very efficient form of clutch consists of a split tube, the parts of which are connected together by a pair of oblique links, making a sort of parallel motion. This form is shown in Fig. 13.

(To be continued.)

ECONOMICS OF PLANNING AND CONSTRUCTING ELECTRIC LIGHT AND POWER STATIONS.*

BY ALEX. P. WRIGHT.

(Continued from page 513.)

The estimate of cost of station already given, it must be understood, is approximate only, and made without reference to plans. It is merely preliminary. The estimate is intended to more than cover the immediate wants of the plant up to the extent of 1,000 horse-power and corresponding dynamo capacity; the station being designed for an ultimate 1,300 horse-power capacity.

The following three estimates are also preliminary, and are based on the conditions enumerated above, which may be respectively designated A., B. and C.

A. being for the immediate output 600 horse-power, B. being for an increased output as provided for in the estimate of cost of plant to the extent of 1,000 horse-power, and C. for the ultimate capacity 1,300 horse-power, with capital increased to $250,000.

The estimate of horse-power hours are deduced from curves of which the diagram already considered is a sample, and in each change has been made in due proportion to the increase.

It has been first assumed that only a small dividend be paid the first year of operation, and an increasing one with the increases which it is assumed will come.

The power required for a full arc lamp is taken as 1 horse-power, for a divided arc 3-4 of a horse-power, and for incandescent lighting 10 lamps are assumed per horse-power.

For motor work it is assumed that 1 horse-power actual will supply 2 horse-power of motors. As a matter of fact, with a sufficiently large number the estimate of power required is smaller, and it may be further stated that not only are all these assumptions of power high, on the general principle that, in estimating, cost should be put high and revenue low; but they can be borne out by the records of over twelve months' run, in a place for which this might be the plan to be taken.

In the course suggested in these articles the time for minute estimation will come after the preliminary estimates and plans based upon them; and it must be borne in mind that in all the outlines so far given and which immediately follow, that they are such as might be elucidated in a preliminary discussion, and as if taken without premeditation. It is proposed to conclude with two or three plans in such detail as the space will allow with more minute estimates following them, with such remarks upon quality of work and material as may arise in discussion of the subject; in fact it has been the writer's object to deal with this matter much as it might be dealt with in the way of discussion, previous to deciding upon a plant.

ESTIMATE A.

Capacity for Distribution.

	H.-P.
60 Full arc (1,200 candle-power) lamps, streets	60
170 Divided arc (1,200 candle-power) lamps, commercial	125
70 horse-power motors	35
4,380 Incandescent lamps (16 candle-power) on 3,650 light dynamo capacity	365
	585

Horse-power hours per annum.

60 Full arcs, streets	222,000
170 Divided arcs, commercial	173,592
70 Horse-power motors	109,550
4,380 Incandescent lamps	917,966
	1,422,838

Capital $230,000, sufficient for 1,000 horse-power capacity to allow for increase.

Lbs. coal per horse-power hour	2 1-4
Cost of coal per ton landed in boiler room	$4.25
Tons coal per annum	1,429
Cost of coal per annum	$6,073.00
Full arc lamp runs 3,700 hours per annum, horse-power hours per annum	3,700
Carbons per full arc lamp per annum	1,100
Full arc lamp carbons, including freight, per 1,000	$12.00
Cost of carbons per full arc lamp per annum	$13.20
Divided arc lamp hours per annum, 1,021 horse-power hours per annum	765 3-4
Carbons per divided arc lamp per annum	306
Divided arc lamp carbons, including freight, per 1,000	$11.00
Average horse-power hours per incandescent lamp per annum	209.5
Average hours per incandescent lamp per annum	2.095

* From *Modern Light and Heat*, Boston, U.S.

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Estimate of Running Expenses.

Labour and salaries		$15,350.00
Maintenance		3,500.00
Taxes		2,500.00
Stationery, &c.		300.00
Coal as above		6,073.00
Sundries		1,000.00
Oil and waste		500.00
		29,223.00
4 per cent. dividend, 1st year		9,200.00
		38,423.00
Trimmers and line man		2,580.00
Carbons, full arc	792	
Divided arc	572	
	230 lamps.	1,364.00
Incandescent renewals		5,670.00
		$48,037.00

Cost of Trimming per Lamp.

Full arc lamps	60	
Divided arc lamps	170	
	230 lamps.	
Costing for trimming $2,580.00	each	$11.22
Cost per horse-power hour		2.7 cents

Cost per full Arc Lamp per annum.

3,700 horse-power hours at 2.7 cents	$99.90	
1,100 carbons at $12.00 per M	13.20	
Trimming	11.22	
		$124.32
Cost per full arc lamp per night		34 cents
Cost per full arc lamp per hour		3 3-10 cents

Cost per Divided Arc Lamps per annum.

765 3-4 horse-power hours at 2.7 cents	$20.68	
306 Carbons at $11.00 per M	3.37	
Trimming	11.22	
		$35.27
Cost per divided arc lamp per night		11 1-4 cts.
Cost per divided arc lamp per hour		3 1-2 cts.

Average cost per Incandescent Lamp per horse-power hour.

2.7 cents 10 lamps per horse-power. Cost per lamp hour	27-100 cts.
Average cost of incandescent lamp per annum	$5.66
Renewals.—2,095 lamp hours. life lamps 900 hours, lamps 55 cts. Total renewals per annum	1.28
Average cost per annum, including renewals	6.94
Average cost per hour, including renewals	1-3 cents
Average cost motors per horse-power per hour	1 35-100 cents
Average cost motors per horse-power per annum	$42.25

ESTIMATE B.

Capacity for Distribution as follows:—

	H.-P.
120 Full arc lamps	120
200 Divided arc lamps	150
140 horse-power motors	70
7,200 Incandescent lamps on 6,000 light dynamo capacity	600
	940

Horse-power hours per annum.

	H.-P. hours
120 Full arc lamps	444,000
200 Divided arc lamps	204,226
140 horse-power motors	219,100
7,200 Incandescent lamps	1,508,541
	2,375,867
Tons coal per annum	2,386
Cost of coal per annum	$10,140.00

Estimate Running Expenses.

Labour and salaries		$15,350.00
Maintenance		3,500.00
Taxes		2.500.00
Stationery		300.00
Coal as above		10,140.00
Sundries		1,000.00
Oil and waste, etc.		800.00
		33,590.00
6 per cent. dividend 2nd year		13,800.00
		47,390.00
Trimmers and line man as before	$2,580	
Extra trimmers	2,730	
Carbons as before	1,364	
Extra carbons	1,192	
Incandescent renewals	5,670	
Extra renewals	3,650	
		17,186.00
		$54,576.00

Cost of Trimming per Lamp.

Full arc lamps, 120. Divided arc lamps, 200 320 lamps.		
Costing for trimming, $3,310.00		$10.25
Cost per horse-power hour		1.95 cents
Cost per full arc lamp per annum:—		
3,700 horse-power hours at 1.95 cents	$72.15	
Carbons as before	13.20	
Trimming	10.35	
		$95.70
Cost per full arc lamp per night		26 1-4 cents
Cost per full arc lamp per hour		2 6-10 cents
Cost per divided arc lamp per annum:—		
765 3-4 horse-power hours at 1.95 cents	$14.93	
Carbons as before	3.37	
Trimming	10.35	
		$28.65
Cost per divided arc lamp per night		.92 cents
Cost per divided arc lamp per hour		2 8-10 cents
Average cost per incandescent lamp hour		.195 cents
Average cost per incandescent lamp per annum		$4.09
Renewals per annum as before		1.28
Average cost per annum, including renewals		5.37
Average cost per hour, including renewals		1-4 cent
Average cost of motors per horse-power per hour		.925 cents
Average cost of motors per horse-power per annum		28.95

ESTIMATE C.

Capital $250,000, increased to equip Station to full capacity.

Capacity for distribution:—

	H.-P.
300 Full arc lamps	300
350 Divided arc lamps	255
8,760 Incandescent lamps on 7,300 light dynamo capacity	730
160 Motors	80
	1,365

Horse-power Hour per Annum.

	H.-P. Hours.
300 Full arc lamps	1,110,000
350 Divided arc lamps	347,184
8,760 Incandescent lamps	1,835,392
160 Horse-power motors	250,400
	3,542,976
Tons coal per annum	3,559
Cost of coal per annum	$15,126.00

Estimate Running Expenses.

Labour and salaries		$15,350.00
Maintenance		3,500.00
Taxes		2,500.00
Stationery		300.00
Coal as above		15,126.00
Sundries		1,000.00
Oil, waste, &c.		1,000.00
		$38,776.00
10 per cent. dividend		25,000.00
		$63,776.00
Trimmers, line man, and as before	$2,580	
Extra trimmers	3,650	
Carbons	5,104	
Incandescent renewals	11,340	
		22,674.00
		$86,450.00

Cost of Trimming per Lamp.

Full arc lamps	300	
Divided arc lamps	350	
	650	
Costing for trimming, $6,230.00	each	$9.43
Cost per horse-power hour		1.8 cents
Cost per full arc lamp per annum:—		
3,700 horse-power hours at $1.8		$66.60
Carbons as before		13.00
Trimming	$9.43	
		$89.23
Cost per full arc lamp per night		24 13 cents
Cost per full arc lamp per hour		2 41-100 cents
Cost per divided arc lamp per annum:—		
765 3-4 horse-power hours at 1.8 cents	$13.78	
Carbons as before	3.37	
Trimming	9.43	
		$26.58
Cost per divided arc lamp per night		.85 cents
Cost per divided arc lamp per hour		26.10 cents
Average cost per incandescent lamp per hour		.18 cents
Average cost per incandescent lamp per annum		$3.77
Renewals per annum		1.23
Average cost per annum, including renewals		5.05
Average cost per hour, including renewals		1.4 cent
Average cost of motors per horse-power hour		.9 cent
Average cost of motors per horse-power per annum		$28.17

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Before proceeding with more detailed and final plans it may be interesting to fix rates for lighting of all classes and power, and then to estimate what profits such rates would bring in each of the three cases A, B, and C.

(To be continued.)

ON AN EFFECT OF LIGHT UPON THE MAGNETISATION OF IRON.*

BY SHELFORD BIDWELL, M.A., F.R.S.

Several experimenters in the early part of the present century tried to magnetise iron and steel by the action of light,† but I do not know of any recent attempts in this direction, and of late years the thing has been generally regarded as impossible. Under ordinary circumstances there can be little doubt that this is the case, but, if a certain condition is fulfilled, we might, I think, expect to find some evidence of the action of radiation upon the magnetism of iron.

The condition is that the susceptibility of the bar A B to be operated upon shall be greater (or less) for a magnetic force in the direction A B than for an equal one in the direction B A. This Paper contains a short preliminary account of a series of experiments which have been undertaken with iron bars having this property. Much yet remains to be done, which will require a considerable amount of time, and for which special apparatus must be constructed. In the meantime the results already obtained appear to possess sufficient interest to justify their publication.

The method of preparing the bars is as follows :—A piece of soft iron rod, which may conveniently be 10 or 12 cm. long, and from 0·5 to 1 cm. in diameter, is raised to a bright yellow heat, and slowly cooled. When cold it is placed inside a solenoid, through which is passed a battery current of sufficient strength to produce a field of about 350 or 400 C.-G.-S. units. The iron when removed from the coil is found to be permanently magnetised, and its north pole is marked for the sake of distinction with red sealing-wax varnish. The bar is then supported horizontally, and in an east and west direction behind a small reflecting magnetometer, and over it is slipped a coil which is shunted with a rheostat, the resistance of which can be gradually increased from 0 to 26 ohms. The coil can be connected by a key with a single battery cell, which is so arranged as to produce a demagnetising force inside the coil. The resistance of the rheostat is slowly raised, so that more and more current passes through the coil, the battery key being alternately lifted and depressed until the magnetometer indicates that the iron bar as a whole is perfectly demagnetised. The strength of the demagnetising force required varies according to circumstances ; it is generally about one-thirtieth or one twenty-fifth of the original magnetising force.

After this treatment the iron rod does not differ, so far as ordinary tests will show, from one which has never been submitted to magnetic influences. Nevertheless, as is well known, it possesses certain properties which distinguish it from a piece of really virgin iron. In the first place, the magnetisation induced by a force acting in such a direction as to make the marked end a north pole is greater than that caused by an equal force in an opposite direction. Again, if such a bar be held horizontally east and west (to avoid terrestrial influences), and tapped with a mallet, the marked end at once becomes a north pole. A similar effect follows if the rod be warmed in the flame of a spirit lamp. Lastly, if it be placed inside a coil and subjected to the action of a series of rather feeble magnetic forces, of equal strength but alternating in direction, the marked end will generally become a north pole, even though the last of the alternate forces may have tended to induce the opposite polarity.

A rod treated as above described appears to be remarkably sensitive to the action of light. When such a rod is placed behind the magnetometer, and illuminated by an oxyhydrogen lamp about 70 cm. distant, there occurs an immediate deflection of from 10 to 200 scale divisions,‡ the magnitude of the effect varying in different specimens of iron. As the action of the light is continued the deflection slowly increases. When the light is shut off, the magnetometer instantly goes back over a range equal to that of the first sudden deflection, then continues to move slowly in the backward direction towards zero.

The first quick movement I believe may be due to the direct action of radiation, and the subsequent slow movement to the gradually rising temperature of the bar. With a thick rod (1 cm. in diameter) the slow movement is barely perceptible, extending over only one or two scale divisions in the course of a minute, the spot of light becoming almost stationary after the first sudden jump. With a thin rod the sudden effect is generally smaller, while the slow after effect is greater, and may continue until the spot of light passes off the scale.

As a general rule the magnetic effect is such as to render the marked end of the rod a north pole ; occasionally, however, it becomes a south pole, but in such cases I have always found that the polarity is comparatively feeble. It may even happen* that the marked end becomes north when certain portions of the rod are illuminated, and south when the light acts upon other portions. This is probably due to irregular annealing and a consequent local reversal of the direction of maximum susceptibility ; it indicates that the light effect is local, and is confined to the illuminated surface. In one remarkable specimen, which happens not to have been annealed at all, the sudden effect and the slow effect are in opposite directions. When the light is turned upon this rod there is at first a sudden deflection of twenty magnetometer-scale-divisions to the left, the spot afterwards moving slowly and steadily towards the right. When the light is shut off there occurs at once a jump of twenty divisions further towards the right before the spot begins to move back in the zero direction.

Some attempts have been made to repeat the experiments with light polarised by means of a Nicol's prism ; but, either because the largest prism at my disposal was too small (its aperture being barely 2 cm.), or because too much of the radiant energy was absorbed by the spar, I failed to get any magnetic effects whatever with the prism in either position.

[Prof. Silvanus Thompson has quite recently been kind enough to lend me a very large and excellent Nicol's prism. From a few experiments already made with this instrument, it appears that the action of the light is quite independent of the plane of polarisation.—March 16.]

There can be no doubt whatever of the reality of the effects here described ; they are perfectly distinct, and are at any time reproducible with certainty. The only question is how much of them is primarily caused by the action of light, and how much by mere incidental change of temperature. But taking all the circumstances into consideration, I think the evidence is in favour of the conclusion that the *instantaneous* magnetic change, which occurs when a prepared iron bar is illuminated, is purely and directly an effect of radiation.

* Paper read before the Royal Society yesterday (Thursday) evening.

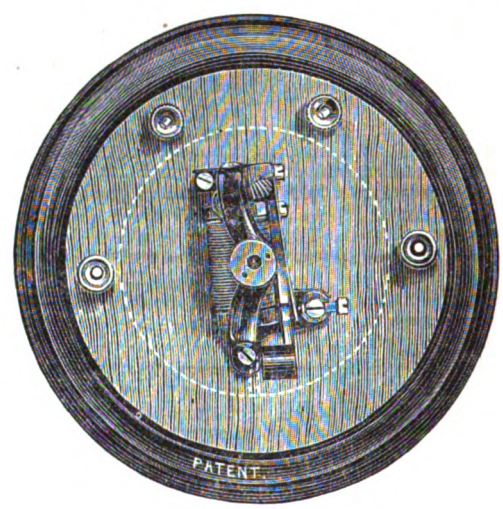
† Chrystal, *Encycl. Britann.*, Vol. XV., p. 274, mentions the following names :—Morichini, Mrs. Somerville, Christie, Riess, and Moser.

‡ The magnetometer mirror was 1 metre distant from the scale, and each division = 0·64 mm. ($\frac{1}{40}$ inch).

* This has been observed in two specimens.

BERRY'S IMPROVED ELECTRIC BELL.

The accompanying figure shows the working parts of an improved form of electric bell brought out by Mr. F. H. Berry, of



Percival-street. It is very neat and compact, the whole of the working parts being hidden beneath the dome, the position of which is shown in the figure by the dotted line. A single bobbin only is used to energise the magnet, and a powerful ring is obtained with one small Leclanché.

BOOKS, &c., RECEIVED.

"*Transactions* of the American Institute of Electrical Engineers. Vol. V." (New York.)

"The Scientific Works of C. William Siemens, Kt." 3 vols. Edited by E. F. Bamber, C.E. (London : John Murray.)

"*Journal* of the Institution of Electrical Engineers." Vol. XVIII., No. 77. (London : E. and F. N. Spon.)

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AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March 9th*, 1889.

It might be expected that after the recent vigorous pronouncement by electric light men at Chicago against the subways, the various municipal authorities would be desirous of going a little more slowly in forcing the companies into the subways. But the contrary appears to be the case. In this city the Mayor, as a member of the Subway Board, has taken to his new duties with a *verve* and a zest that are in remarkable contrast with the apathy shown by his predecessor. Mayor Grant figures at the present time very much like some of those Eastern despots whose leading remark in conversation was "Off with his head," for he no sooner hears that some poor offender has been guilty of tardiness in getting into the conduits than he immediately threatens him with all the penalties of the law and several other things besides. The Subway Board appear very glad to have this assistance from the Mayor, but it begins to look as if his precipitancy will presently land them in an awkward predicament. This week the meeting of the Board was the scene of a terrible conflict of ugly words between the Mayor and Commissioner Gibbons and Mr. Lynch, the president of the United States Company. Mr. Gibbons made certain statements as to the contumacious behaviour of the company, whereupon Mr. Lynch gave him the lie direct, and when Mr. Gibbons added that he based his statement on his conscience and his judgment, Mr. Lynch told him that it was "a poor foundation." As may be easily believed such amenities as these are not leading to a very peaceful solution of the difficulties that beset the underground wires in this city. In Philadelphia there is prospect of a not less unenviable state of affairs. A Bill is now pending before the Pennsylvania Legislature, providing, under a penalty of $500 a day for delay, that all the wires in cities of more than 30,000 inhabitants in that State shall be placed underground by August. This is, of course, the sheerest absurdity in the way of legislation; but it begins to look as though the law may pass, in which case the authorities in Philadelphia will have to bury 12,000 miles of wire in less than six months, at a cost certainly exceeding $5,000,000, tearing up the streets and paving in every direction, paralysing all kinds of electric service, and rendering life a misery and a burden as much to citizens as to the companies at whom the blow is aimed.

Quite an interesting event occurred at Baltimore a few days ago, during the celebration of the thirteenth anniversary of Johns Hopkins' University, when Prof. H. A. Rowland delivered an address on "Modern views with respect to electric currents." This address, which has not yet been given out for publication, placed him in line with Sir William Thomson and others in regard to the latest theories on the nature of electricity, and was rendered the more valuable from being illustrated by a number of experiments. I think I may best give an idea of Prof. Rowland's views by the following brief quotation:—"We have thus done away with action at a distance, and have accounted for magnetic action by a change in the intervening medium, as Faraday partly did almost fifty years ago. For this change in the surrounding medium is as much a part of the electric current as anything that goes on within the wire. When we use the electric light to illuminate our streets it is the luminiferous ether which conveys the energy along the wire, as well as transmits it to our eye after it has assumed the form of light. When the wire falls to the ground, as it is sure to do sometimes, and it is touched by some unfortunate man or horse, it is the luminiferous ether which sounds his death knell. We step upon an electric street car, and feel it driven forward with the power of many horses, and again, it is the luminiferous ether whose immense force we have brought under our control and made to serve our purpose—no longer a feeble, uncertain sort of medium, but a mighty power, extending through all space, and binding the whole universe together, so that it becomes a living unit, in which no one portion can be changed without ultimately involving every other portion."

An interesting Paper was presented at the last meeting of the New York Railway Club by Dr. H. R. Waite, of the Julien Company, on "Electric Train Lighting." Dr. Waite mentioned the fact that the Railway Car Lighting and Signal Company, using the Julien battery, had recently fitted up two vestibule trains on the Chicago, Milwaukee and St. Paul Road with a lighting plant on the method devised by Mr. Barrett, comprising a Brotherhood engine and a special generator furnishing current to 448 cells placed in convenient numbers in trays beneath the fourteen cars of each train. The same system of supplying to the battery has been in use for some time on the Connecticut Riverhead Railroad, and has made a very favourable showing of expenses as compared with oil lighting. The cars illuminated are in this case those employed for the ordinary passenger traffic. Dr. Waite's figures show that oil lighting for the same train on that road takes a total outlay of $925 per annum, whereas the cost by electricity was $330, or adding the expenditure for coal, &c., in generating steam $486, leaving a difference in favour of electric lighting of $439 per annum. In other words, for this ordinary train electric lighting costs $6·84 per lamp per year of 310 days, or 2·2 cents per lamp per day, while the oil lamp costs $13·3 per lamp per annum, or 4·2 cents per lamp per day. Of course electric lighting on special trains would be more costly than on ordinary trains, but even there, it stands to reason, the advantages would be on the side of the electricity on all the scores of safety, health, comfort and high illuminating efficiency. It appears from Dr. Waite's Paper that the depreciation on the entire electric plant of this character amounts to less than 5 per cent. per annum, the plant is question being estimated at an original outlay of $2,500.

There is remarkable activity with the opening of spring in the electrical railway field, in fact the boom in this department promises to be something terrific. I notice that the *Electrical World* illustrates this week no fewer than six new railroads, while its columns week by week contain notes of scores of new projects everywhere. It is mentioned in one of the articles that on the electric railroad at Wichita, Kan., a brush has been in continuous use on one of the motors for the period of 65 days, making a total run of 4,300 miles. This is pretty good work for a motor brush, and I see it stated that the Thomson-Houston Company are now introducing carbon brushes in place of those made of copper. The idea of using carbon brushes instead of copper on dynamo electric machines is not a new one, and, in fact, seemed with the progress of the art to have fallen into disfavour, but the rapid introduction of motors has given it new life and popularity. While the brushes of the dynamos are generally under frequent inspection and easy to get at, those of a motor which is placed under the car are generally hard to get at and not very easy to see. Hence it happens that carbon has come into use again, and the record made with it on several Thomson-Houston roads appears to be most encouraging for its more extended use. It is stated that the carbon brush or block has a longer life than the copper brush, and has a much better effect upon the commutator, causing it to present a smooth glazed surface, which virtually requires no oil or other lubricant.

I believe I have already advised you of the fact that an attack has been made on the Edison patents in Canada by the Westinghouse and other interests, on the ground that the main patent there is null and void from the failure of the company to manufacture its apparatus within one year, as required by the Canadian patent law. Information reached this city to-day (Friday) to the effect that Mr. Pope, the Commissioner of Patents, before whom a large amount of evidence *pro* and *con* has been submitted, has decided that the patent has been invalidated for the reasons named, and that it must therefore be cancelled. The effect of this decision is to throw the incandescent business open in Canada, and it is also claimed that it will have a reflex action on the status of the patent in this country.

Although we have nearly completed the first quarter of the year, and have our usual number of murders, no case has yet occurred for record or study of execution by electricity. It might seem as though the law had fallen into "innocuous desuetude," but I suppose we shall hear something about it soon. In the meantime one or two of the other States such

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as Ohio and Missouri, are prepared to follow the example of New York, but in Illinois a considerable spirit of opposition to the idea has manifested itself. At a meeting of doctors during the past week in Chicago, the subject came up for discussion, and the medical men, by a large majority, declared themselves against electrical executions, voting, moreover, to send their resolutions on the subject to the Governor of the State.

I hear from Boston that the greatest interest is taken there in commercial and electrical circles in the development of the Thomson welding system. The factory at Lynn, adjoining the huge works of the Thomson-Houston Electric Company, is already full of machinery, and is as busily occupied as possible in the manufacture of the apparatus. The stock of the company is in great demand, and I believe it is now quoted at a premium of 200 or 300 per cent. There seems no reason whatever to doubt that the company has a great career before it, and that there is destined to be an immense demand for electric welding.

Mr. Charles G. Burke, who is well-known here as a persistent experimenter in telegraphic and cable improvements, has been conducting for about a year a series of elaborate experiments and trials with his new cable relays over the cable of the Direct United States Company, between Rye Beach, New Hampshire, and Halifax, Nova Scotia. Mr. Burke was in this city last week, and reports having succeeded in demonstrating the fact that Morse telegraphy by sound is practicable over the longest cable, at a speed at least as great as that of the Mirror and Siphon Recorder. On February 17th he tried one of his relays for the first time on the main Atlantic cable of the same company between Halifax and Ireland, a distance of 2,500 miles; and a local circuit and an ordinary Morse sounder were operated without difficulty. It is stated that the make and break of the local circuit were just as prompt, firm, and accurate as they would have been on a land line, and this without any increase in the battery power ordinarily used in the operation of the mirror. Mr. Burke is now having a number of instruments completed for the purpose of establishing a complete circuit between New York and London, from which the messages are to be sent direct without the intervention of operators at intermediate stations, and received at their destination by sound in the ordinary manner. It is understood that the Direct Company will have an interest in these improved inventions, and it certainly will be worth having should the statements which I have cited be substantiated to any material extent.

SCANDINAVIAN NOTES.

(FROM OUR CORRESPONDENT.)

The Copenhagen Telephone Company has for some time been in negotiation with the Corporation as to the conditions on which they might be allowed to use the streets for telephone wires. An agreement containing some very stringent clauses has now been entered into. The agreement holds good for thirty years from January 1st, 1888, and after its expiry all wires must be removed, unless fresh arrangements are made. The concession is a most one-sided affair, and it is no wonder that the company required a long time to stomach it.

The minimum charge for inland telegrams in Sweden has been reduced to 50 öre (6¾d.) from the beginning of this year. The result is a vast increase in the number of telegrams despatched. In the town of Norrkögring the inland telegrams during January exceeded those of January last year by 50 per cent., and in Helsingborg the increase was still greater, the figures being 1,065 for January this year, against 515 for January last year, the receipts having simultaneously risen from 529kr. to 753kr.

In Russia every telephone proprietor has to pay an annual tax to the Government of 100 roubles. In some of the Baltic provinces one large payment may take the place of the annual tax; in Reval, for instance, a payment of 9,000 roubles procures the right to erect a telephone. A large Swedish electrical engineer had recently fixed an experimental telephone between two houses in Reval, but had to quit the town with very short notice, leaving his telephone behind him, so as not to be made to pay the fee.

Mr. L. M. Eriksson, of Stockholm, whose telephone is so well known, has recently introduced further improvements in his instrument. Some three years ago Mr. Eriksson constructed a new microphone, with the object of avoiding the somewhat frequent adjustment which was necessary with the older form. The improved microphone consisted of a number of vertical carbon rods resting upon a horizontal one. This instrument did not come into general use, and was never adopted by the Stockholm Telephone Company, but the new telephone of Mr. Eriksson is understood to be a distinct improvement, both as regards the transmission of sound and the adjustment. The membrane presses against some grains of carbon, giving rise to the variable electric resistances during speaking which are necessary for transmission of sound. This form of microphone transmits and moderates the sound exceedingly well. A weak voice seems to be strengthened, and very loud exclamations reach the receiver subdued, but perfectly distinct. The adjustment of the microphone is effected by turning it half round, whereby the carbon grains are made to revolve, resulting in fresh points of contact; it can be fixed on the ordinary telephones, but as the construction has not yet been thoroughly tested for any length of time, it might be premature to guarantee its keeping all the good qualities which the first specimens undoubtedly possess. Should these good points be confirmed by further testing, there can hardly be any doubt that this latest invention of Mr. Eriksson will make a mark.

A Swedish factory (Liljeholmens Stubinfabrik) has commenced to make electric cables. On a recent occasion they delivered 2,200 metres of cable to a Stockholm firm, some with nineteen and some with thirty-six copper wires. The insulation appears to be everything that can be desired, and several important orders have recently been completed.

CORRESPONDENCE.

PROF. JOSEPH HENRY'S RESEARCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whilst the recollection of Dr. Lodge's lecture at the Royal Institution is fresh in the memory of those who heard it, permit me to extend a remark which fell from the lecturer with respect to Prof. Henry's observations on inductive discharges. It will be remembered that *apropos* of the impromptu experiment which arose from the unexpected behaviour of the Royal Institution theatre wall paper Dr. Lodge mentioned that Prof. Henry had observed that a discharge in an upper room of a house caused sparks in an independent circuit in a cellar.

The full account of Prof. Henry's observation is to be found in the "Scientific Writings" of Prof. Henry, Vol. I., p. 200 (Washington, 1886), in a short Paper, entitled, "On Induction from Ordinary Electricity and on the Oscillatory Discharge." It was pointed out by Mr. Raine in *The Electrician* of November 2nd, 1888, that Prof. Henry was undoubtedly acquainted with the oscillatory nature of Leyden jar discharges, and that fully fourteen or fifteen years before Sir W. Thomson's important paper in the *Phil. Mag.* Here is the whole passage taken verbatim from Henry's paper referring to inductive discharges:—

"In extending the researches relative to this part of the investigation a remarkable result was obtained in regard to the distance at which inductive effects are produced by a very small quantity of electricity. A single spark from the prime conductor of the machine of about an inch long thrown on the end of a circuit of wire in an upper room produced an induction sufficiently powerful to magnetise needles in a parallel circuit of wire placed in a cellar beneath at a perpendicular distance of 30ft. through two floors and ceilings each 14in. thick. The author is disposed to adopt the hypothesis of an *electrical plenum*, and from the foregoing experiment it appears that the transfer of a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000ft. capacity, and when it is considered that the magnetising of the needle is the result of the difference of two actions it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

This remarkable experiment of Henry's shows how very near he came to the starting point of the investigations, which have occupied Dr. Hertz for the last few years, and that his notion of an electrical plenum, and the analogy of its disturbance with the diffusion of light, brought him almost within touch of modern views. We must at any rate credit Henry with having a perfectly clear conception of the oscillatory form of the discharge, and with having experimentally, though not

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with quite definite knowledge of the subject, obtained inductive sparks by the aid of a resonant circuit and oscillatory discharges.—Yours, &c., J. A. FLEMING.

University College, London.

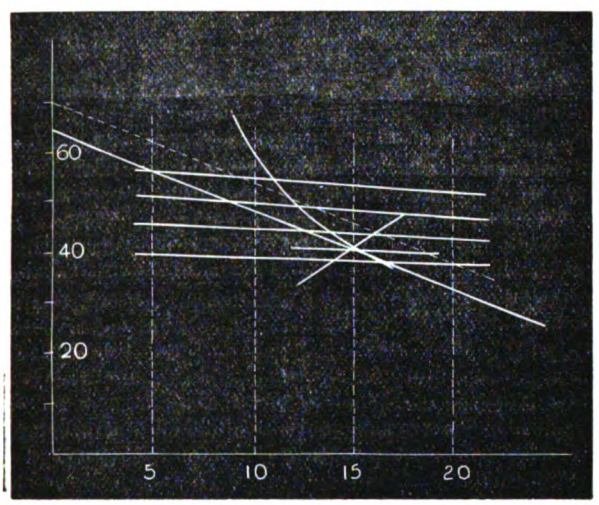
THE THEORY OF THE ARC LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the very interesting Paper on arc lamps, read by Prof. Silvanus P. Thompson at the Society of Arts meeting on the 6th inst., the author objected to arc lamps being regulated by the difference between the current and the E.M.F., and suggested that it would be better to regulate the arc so as to make the product of those quantities equal, and that the attempt at product regulation was essentially better than regulation by distance.

The Paper, however, does not attempt to show the electrical conditions under which the mechanism of an arc lamp acts. Nor do I remember to have seen this described. Had this matter been examined, it seems to me that the "equal watt" lamp suggested could have been shown to be no improvement on the "differential" lamps.

In the accompanying diagram let the horizontal distance represent amperes and the vertical volts as figured.



The four slightly inclined lines approximately represent at any point the relation between the volts and amperes, if the carbons be fixed successively at one-tenth, two-tenths, three-tenths, and four-tenths of an inch from each other, and the current increased from 5 to 20 amperes. Call these the carbon characteristics, or *carbon lines*.

Suppose the E.M.F. of the armature to be 65 volts, the current between the carbons 15 amperes, and the width of arc ·15, as illustrated on the diagram. The inclined line drawn from 65 volts may be called the *current line*, because it shows all the possible relations between the current and E.M.F.

The fall of E.M.F. as the current increases is, of course, due to resistance in the circuit. (In this case, say,

$$\frac{65-43}{15} = 1{\cdot}5 \text{ ohms}).$$

Since the carbon lines slightly fall it is impossible with an uniform E.M.F. to obtain a fixed arc. Moreover, an increase in the conductivity of the arc, such as by commencing to give off gas, would be represented, for the time, by making the carbon line more inclined. Hence, to make a steady arc, the decrease of E.M.F. with an increasing current between the carbon points due to any cause must be less than the decrease of E.M.F. with an increasing current due to the circuit resistance.

In the diagram the less the angle at which "current line" cuts the "carbon line," the less steady will be the arc, and the greater the angle the steadier the arc.

The position of the "current line" shows two things; first, the steadiness of the arc; second, when it cuts the successive "carbon lines" it shows the current when the arc is four-tenths, three-tenths, two-tenths, and one-tenth of an inch wide.

The mechanism of the arc lamps has nothing to do with these relations. The arc is regulated by the E.M.F. of the armature and the resistance of the circuit to certain definite relations of current and E.M.F. It is also rendered stable by the resistance of the circuit.

Suppose the lamp simply regulated by feeding when the current fell below 15 amperes. Then the vertical line at 15 amperes may be called the lamp "*feed*" *line*.

Or, suppose the lamp simply regulated by feeding when the E.M.F. fell below, say, 43 volts for an arc ·15 long and 15 amperes. Then the horizontal line at 43 volts is the lamp "*feed*" *line*.

So long as the E.M.F. of the dynamo was constant one lamp would regulate as well as the other.

Suppose there were no retractile feed, and that the E.M.F. varied and rose to 70 volts, this is illustrated by the dotted "current" line.

It is easy to see from the diagram, by noticing where the imaginary ·15 "carbon line" cuts the upper "current line," that the E.M.F. between the carbons would slightly decrease and the current rise to about 17 amperes. As the carbons burned away the second lamp, assumed above, would soon recommence regulating at about 16 amperes, and nearly the same length of arc. The first lamp would not regulate until the carbons had burned about ·25 apart.

Next, suppose the lamp had a differential feed and a retractile motion. In this lamp if the E.M.F. increase so also must the current. As the gear is always in the same position at the moment of feeding, the *feed-line* of this lamp is shown by the upward inclined line, which may be a curve, and its incline regulated by the designer or adjuster of the lamp. Judged by the diagram, an increase of 5 volts would cause the carbon to separate rather less than one-twentieth, and the current to increase to about 18 amperes, and very soon the lamp will be again feeding with about 17·5 amperes with ·2 arc. This is a much better regulation than before. If either of the first lamps had a retractile motion its "feed line" would be represented by an upward incline, and it would give as good regulation if running in parallel. The great advantage of the differential lamps is that they run so well in series.

In Prof. Silvanus P. Thompson's ideal equal watt lamp the "feed line" would be represented by the hyperbolic curve, and the effect of a rise of 5 volts would be to draw back the carbons about one-fifth, making an arc three-tenths of an inch long, with about 13 amperes and 50 volts.

Which would be most agreeable, this long purple arc with a tendency to flame or the brightened but steady arc of the differential lamp? Hence it may be concluded that with a small variation of E.M.F. the disparaged "differential" lamp would at least do as well as the equal watt lamp, and with a considerable variation of E.M.F. it would do much better.

The illustrative diagram here given does not pretend to give precise results, but merely represents a rough average of discordant experiments, and illustrates the average tendency rather than the precise results.—Yours, &c., WILSON HARTNELL.

March 18, 1889.

ON THE DESIGNING OF CONTINUOUS-CURRENT DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much obliged to Mr. Geipel for kindly drawing attention to the omission of a 2 in one of the formulæ and examples contained in my Paper on the above subject. Regarding his remarks about the alteration of magnetic resistance with different degrees of magnetisation, and the consequent variation of Kapp's Coefficient 2, you will observe when you get the next number of the monthly *Transactions* of the Institution of Engineers and Shipbuilders, that I explained these points prior to the discussion upon my Paper.

The Paper did not embrace the calculations for magnetisation curves, but simply considered the case of dynamo working at full power, where the values given and found fitted in very well with Kapp's Constants.—Yours, &c.,

ANDREW JAMIESON.

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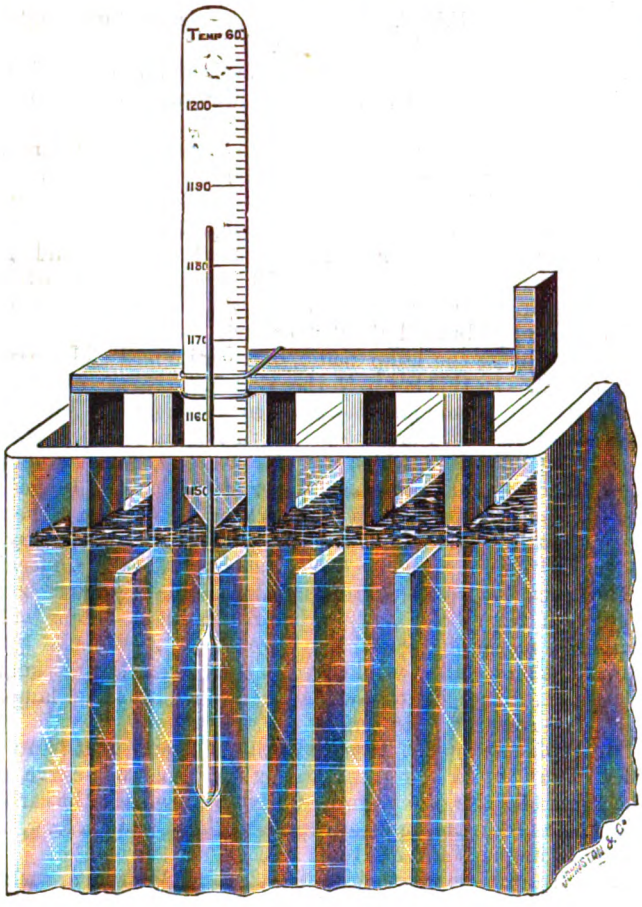
THE HOLDEN HYDROMETER.

This hydrometer, which has been designed by Captain Holden, R.A., specially for secondary batteries, and has been in use for the last year or so, consists of two parts, viz., hydrometer float and scale. In use the latter is clipped to the plates by an india rubber ring and then pushed down until the point at the lower end touches the liquid. The density is then read by the position of the top of the hydrometer stem on the scale (*see* Fig.) The scale is very open, one degree being represented by a tenth or even a quarter of an inch. It is made in glass and ebonite, the former



The Holden Hydrometer.

being the more accurate while the latter is the less fragile. These hydrometers are made by the well-known barometer maker, Mr. Pilkin.

COMPANIES' MEETINGS & REPORTS.

Brazilian Submarine Telegraph Company (Limited).

An extraordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Tuesday, for the purpose of ratifying an agreement, dated the 8th inst., made between this Company and the Western and Brazilian Telegraph Company (Limited), with respect to the working of the lines of the two Companies and the division of the traffic receipts thereof. Viscount Monck presided.

The SECRETARY (Mr. Richard Collett) having read the notice convening the meeting,

The CHAIRMAN said that he remembered once, at a time of political crisis in the House of Commons, when considerable communication was going on between the heads of the different parties, Mr. Gladstone was subjected to a severe cross-examination as to the state of affairs. He prefaced his answer by saying that he found it rather difficult to carry on delicate communications in a glass beehive. It seemed to him that the position of a director of a company was of the same character. The directors were constantly asked in meetings like the present to give an account with great minuteness of the manner in which their transactions were carried on. Although, however, there might be nothing whatever that it was desirable to conceal on its own account, yet he put it to them, as men of business, whether any private individual would carry on his transactions under these conditions. No one liked to admit that he was losing by his business, and if they showed great gains it might have the effect—particularly in a business like theirs—of attracting competition, which would very likely interfere with their future profits. The Directors could not communicate the nature of their transactions to the shareholders without at the same time taking the public into their confidence, and that, without their having anything to say which was in itself at all disagreeable, might be very injurious to the interests of the shareholders. The only way in which he could conceive that that difficulty might be got over was by an extension of confidence on the part of the shareholders to the Directors. For sixteen years the Board had managed the affairs of the Company, and he ventured to say that the shareholders would not disagree from the statement that the Directors' management had not been, on the whole, unsuccessful. He therefore asked them to accept the assurance of the Directors and himself that the engagement which they had entered into with the Western and Brazilian Company was for the benefit of their respective concerns. The Western and Brazilian Company was started at the same time as their own Company, and from the beginning up to now they had been working in intimate relations with that Company. Perhaps the shareholders were also aware that the concession of the Brazilian Submarine Company from the Brazilian Government, which gave them at present a monopoly of the traffic to Brazil, would terminate in four years from next June.

The SOLICITOR (Mr. Burt): The monopoly right.

The CHAIRMAN: Yes. The termination of that concession would not prevent the Company from working to Brazil, but it would terminate their monopoly right to work to Brazil. For some reason, however—he did not know how the fact originated—the concession of the Western and Brazilian Company lasted for 40 years longer, so that that Company had the monopoly of their rights for that period longer than the Brazilian Submarine Company had theirs. Hitherto they had worked with the Western and Brazilian Company on the plan of taking a certain proportion of the receipts of that Company, and giving the latter a certain proportion of the Brazilian Submarine Company's receipts; but it was now wanted to make the connection permanent and more intimate. Their future relations would, under the proposed agreement, be regulated by the receipts being paid into a joint purse, each Company taking a certain proportion of the receipts, the proportions being 54 to the Brazilian Submarine Company, and 46 to the Western and Brazilian Company. The agreement embodied several articles for giving thorough effect to that arrangement, and it

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SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
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PHOSPHOR BRONZE.
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BEARINGS, BUSHES,
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contained one article to which he attached great importance—an article enabling the Brazilian Government to come into the arrangement if they should wish to do so on terms to be agreed upon. If that article could be carried into effect, it would undoubtedly place both Companies in a very advantageous position; but the Brazilian Government had not as yet shown much wish to give its adhesion to that article. They must hope that the Government would be better advised in the future, and meantime the agreement would place the two Companies on a very satisfactory basis for the future conduct of their trade. The Western and Brazilian Company, as hitherto, would be collectors for the Brazilian Submarine Company at the other end of the line, and would be bound to give them every message sent to them to convey to Europe; and the Brazilian Submarine Company would act in a similar way with respect to the other Company, and would hand to that Company the messages received by them for Brazil.

The SOLICITOR (at the request of the Chairman) then read the agreement, which set out—in addition to the facts mentioned by the Chairman—that new cables would be laid by the Western and Brazilian Company as soon as they could, but within two years of the date of the agreement, from Pernambuco to Bahia, from Bahia to Rio de Janeiro, and between Rio Grande do Sul and Monte Video. It was understood that the agreement was simply for a joint working arrangement and was not an amalgamation; and the agreement would take effect as from the 1st of March, 1889.

The CHAIRMAN then moved the following resolution :—

"*That the agreement dated March 8, 1889, and made between this Company of the one part and the Western and Brazilian Telegraph Company (Limited) of the other part, with respect to the working of the lines of the two Companies and the division of the traffic receipts thereof (which agreement has been read to this meeting), be and the same is hereby ratified.*"

Sir JAMES ANDERSON said he had great pleasure in seconding the motion. It had taken several years to bring matters to the present position. He was sure they would do well to approve the agreement.

The CHAIRMAN put the resolution, which was at once carried unanimously, without discussion.

On the motion of Mr. J. G. GRIFFITHS, seconded by Capt. BLAKEY, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN acknowledged the compliment, and the proceedings then terminated.

The Western Counties and South Wales Telephone Company (Limited).

Report of the directors for the year ended 31st December, 1888, to be presented to the shareholders at the fourth annual ordinary general meeting to be held at the Grand Hotel, Broad Street, Bristol, on the 27th inst at two o'clock :—

Capital Expenditure.—The capital expenditure for the year ended the 31st December, 1888, has been £27,885. 3s. 6d., making a total of £113,176. 0s. 2d. to date.

Revenue.—The gross revenue of the company for the year 1888 was £32,206. 9s. 7d., against £23,597. 10s. 5d. for the year ended 31st December, 1887. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond 31st December, 1888, is £10,403. 7s. 1d., against £8,043. 14s. 1d. in previous year's balance-sheet.

Working Expenses.—The working expenses for the year 1888, have been £8,337. 15s. 3d., against £6,693. 8s. 3d. for the year ended 31st December, 1887.

Dividend.—Balance of Net Revenue Account	£8,798	12	8
Dividend of 6 per cent. on the paid-up Preference Share Capital for the year ended 31st December, 1888	5,945	14	3
Balance for appropriation, as per statement at end of accounts	£2,852	18	5

Ordinary Capital.—The Directors recommend a dividend of half per cent. per annum on the Ordinary Share Capital, amounting to £1,405. 19s. 9d., and that the sum of £200 be placed to the Special Reserve Fund, carrying forward £1,246. 18s. 8d. to next year.

Growth of Business.—It will be seen from the following figures that the growth of the business of the Company for the past year has been satisfactory; the number of subscribers to the Company's exchange system having considerably increased, while there has also been a good addition to the number of Private Line Renters. The subscribers to the various exchanges and the Private Line Renters on the 31st December, 1888, and on the 31st December, 1887 (including orders on hand), were as follows :—

	Exchange.	Private.	Total.
December 31st, 1888	2,054	556	2,610
December 31st, 1887	1,572	462	2,034
Increase in 1888	482	94	576

Mileage of Trunk and Renters' Wires—

Erected up to 31st December, 1888	3,109 miles
" " 31st December, 1887	2,140 "
Increase in 1888	969 "

Trunk Lines.—The company has increased its Trunk system, so that on thn 31st December, 1888, it had 283 miles of Trunk pole lines connecting towns with each other, carrying 1,387 miles of wire; against 224 miles of Pole lines, carrying 922 miles of wire, at the corresponding date in the previous year.

The Directors announce a further extension of business, and the report, which is full of useful details of the Company's existing and projected lines, announces that the Company have received numerous inquiries for a connection between the principal towns of their district and the metropolis, and negotiations are pending with the United Telephone Company for the construction of the line. It is also intended to connect Bournemouth, Southampton, and Portsmouth with London, *viâ* Winchester. The Directors further say that inquiries have also been received for connection with Birmingham, Manchester and Liverpool; and should circumstances warrant the expenditure, the Company will proceed to make the necessary arrangements.

Mr. Mark Whitwill and Commander D. M. Forsyth, retire by rotation, but are eligible for re-election. Messrs. Hudson Smith, Briggs and Co. retire, but are eligible for re-election.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 15th, 1889, amounted to £5,148.

MONTE VIDEO TELEPHONE COMPANY.—This company announces an interim dividend at the rate of 6 per cent. to December 31 last on their Preference shares, payable on and after the 25rd inst.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 15th, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,074.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts for the half-month ended March 15th, 1889, were £3,680, against £3,337 for the corresponding period last year.

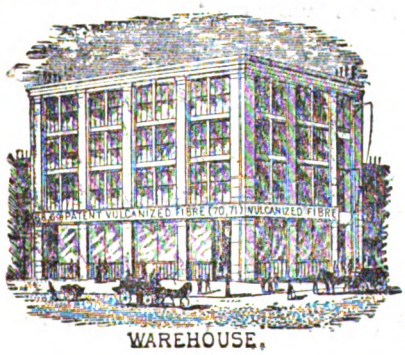
Messrs. F. Wiggins and Sons, the well-known mica merchants, of 10, Tower-hill, London, E., announce that, owing to increased business, they have taken additional premises at 102, Minories, which are in telephone communication with their old premises.

Messrs. Laing, Wharton and Down inform us that that portion of their business relating to the Thomson-Houston system of electric lighting has now been formed into a limited company, under the title of the Laing, Wharton and Down Construction Syndicate (Limited), with a capital of £40,000. None of the shares will, however, be offered to the public, as the whole of the issue, viz., £30,000, has been privately subscribed.

CHANGES OF ADDRESS.—We are informed that the offices, warehouse and show rooms of the General Electric Company (G. Binswanger and Co.) have been removed to 71, Queen Victoria-street, E.C.

———We are informed that the engineer's office of the Metropolitan Electric Supply Company is now at 4, Waterloo-place, S.W.

THE NON-CONDUCTOR OF ELECTRICITY.



WAREHOUSE.

VULCANISED FIBRE,

PATENTED.

This new material is supplied in two qualities, Flexible and Hard.

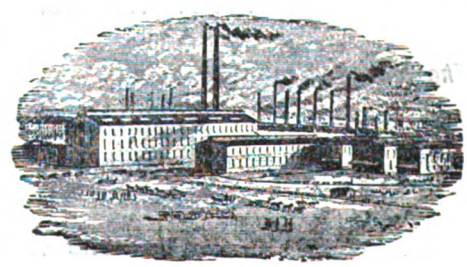
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.

The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.

Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.


FACTORY.

MOSSES & MITCHELL, 70 Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend	Name	Price, Wednesday, Mar. 20, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Mar. 20, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	15/0	Anglo-American	48½ 49½	3 5 8	Jan., Apr., July, Oct.	...	...
2,614,820	Stock	30/0	Do. Preferred	82 83	3 18 4	,, ,,	...	...
2,614,820	Stock	15/0	Do. Deferred	16½ 17	...	February	...	...
130,000	£10	3/0	Brazilian Submarine	13⅝ 13⅞	5 1 0	Mar., June, Oct., Dec.	13¼	...
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	108½	...
16,000	10	9/0	Cuba Submarine	14 14½	6 4 2	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9⅞ 10⅛	3 19 0	Jan., Apr., July, Oct.	10⅛	9⅞
380,000	10	2/6	Eastern	12⅝ 13⅛	4 11 9	,, ,,	13⅛	12⅞
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	...	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	107	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	...	...
250,000	10	2/6	Eastern Extension	12⅞ 13⅛	4 19 1	Jan., Apr., July, Oct.	13⅛	12 15/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust	6⅞ 7⅛	5 1 9	Jan., Apr., July, Oct.	7 3/16	7
178,992	10	3/0	Do. 6 per Cent. Preference	14⅛ 14⅜	4 2 9	,, ,,	14 7/16	14⅛
150,000	10	5/0	Great Northern	14⅝ 15⅛	4 18 4	Jan., July, and April	...	...
17,000	25	12/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	6¾ 7¼	5 10 6	April and October	7⅛	7
15,609	10	3/0 1887	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	...	...
30,000	10	6/0	West Coast of America	9⅜ 10¼	4 17 7	January and July	10 1/16	9⅞
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜ 1⅝	...	...	1⅜	1 13/16
34,563	10	12/0*	Do. 1st Preference 6%	10⅜ 11¼	...	April and October	11¼	11
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	12¾ 13¼	5 13 4	March & September	14 1/16	13
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	5%	Consolidated Telephone and Maintenance	⅜ ⅞	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	⅜ ½	2 14 11	...	7/16	...
80,000	5	5/0	United	15⅛ 15⅜	4 17 7	June and December	15½	15
55,000	5	3/0	United River Plate	5⅜ 5⅝	...	January and July	5⅝	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3½ 3¾	...	...	3⅝	3 5/16
23,692	5	2/0	Do. (fully paid)	4½ 4¾	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	2¾	2 1/16
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42½	41⅝
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works xd	17½ 18½	5 8 1	February & August	18	17⅝

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
Hammond & Co.
J. G. Statter & Co., Limited.

MANVILLE & MADGEN, *Managing Directors.*

3, Prince's Mansions, Victoria Street, Westminster.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 567.—Vol. XXII. FRIDAY, MARCH 29, 1889. Price Fourpence.

NOTES.

The discusssion on Prof. Forbes' Paper on Central Station Lighting, at the Institution of Electrical Engineers—which was concluded last week—has been on the whole of a disappointing character. From the importance and interest of the subject, and the general character and scope of the Paper, we had anticipated a discussion which might take rank as one of the most memorable of recent years; but this was very far from being the case. The majority of the speakers seemed to think it their duty, or their interest, to maintain that Prof. Forbes was wholly mistaken in supposing that English electricians had anything to learn from their Continental brethren. This may, perhaps, be patriotic, but we confess that to us it appears simply childish. Those who fancied themselves aggrieved may derive consolation from the reflection that Prof. Forbes distinctly implied that in not a few cases the lesson of how not to do it is the one that is chiefly impressed by a study of the detail of the Continental stations; and if he refrained from laying emphasis on these points, doubtless it was a sense of courtesy which restrained him. We mention this matter chiefly because we think it unfair and absurd that Prof. Forbes should be supposed to cherish an unreasoning admiration for everything that has been done abroad, or an equally unreasoning depreciation of what has been done at home. We fail to trace any such feeling in the Paper in question.

Perhaps the most important lesson of which Prof. Forbes has spoken is that of the absolute necessity for the use of feeders or of some equivalent means of equalising potential in all but the very smallest networks—a necessity which is common alike to direct and alternating systems. That this question has been unduly neglected in this country both in respect of theory and practice is certainly true. We are not aware of a single instance of the actual use of feeders in this country at the present time. It is, no doubt, true that as yet the majority of our central stations are upon so small a scale that the potential can be kept fairly constant without such devices; but it is nevertheless certain that already the Board of Trade standard of maximum variation is frequently exceeded. Probably before the year is over some appointments will have been made to the office of Electrical Inspectors, and then we shall doubtless hear more about this matter. Meanwhile, in planning new stations we trust that Prof. Forbes' recommendations will receive due consideration.

That the feeder method of regulation does not in itself constitute an ideal system will scarcely be disputed by anyone, and numerous efforts have in fact been made to obtain a more efficient and less costly mode of securing constancy of potential. Hitherto no practical success has been attained in this direction; but from our excellent contemporary the *Electrical World*, of New York, we now learn that at the new Edison station at Easton, Pa., a novel and successful method of regulation has been adopted, in which feeders are entirely dispensed with. Unfortunately no details have yet been made known, but our contemporary states that the device secures absolutely constant potential throughout the system.

This, however, is not the only attempt which has recently been made to improve upon the existing methods of regulation in the case of low-tension distribution. At a recent meeting of the Berlin Elektrotechnische Verein, M. Lahmeyer read a Paper in which he described an ingenious potential regulator devised by himself, and used with much success by his firm in extending the operations of their central station at Rostock. M. Lahmeyer employs a compound-wound dynamo, which he inserts in the compensating circuit. The armature and thick wire coils are in series with the lamps and the shunt coils are taken off the main circuit of the central station; the two coils are wound in opposition, and are so arranged that when the compensating circuit is at full load the series and shunt-windings exactly balance. Below full load the shunt coils predominate and the E.M.F. of the compensating dynamo is counter to that of the main circuit; above full load the direction of magnetisation is reversed by the predominance of the series coils, and the auxiliary E.M.F. assists the main E.M.F. M. Lahmeyer also employs a simple series-wound machine, the E.M.F. of which always assists that of the main circuit; then as the fall of potential in the feeder is proportional to the current, and as the E.M.F. of the dynamo is within certain limits also proportional to the current, it follows that the E.M.F. generated by the auxiliary machine can be made to exactly compensate for the fall of potential. It will thus be seen that a wide variation of load is attainable without the difference of potential at the lamp terminals being affected. It is obvious that the field-magnets of the compensating dynamos must never anything like approach saturation, and we gather that they are made with an exceptionally large cross-section.

The chief objection which the practical electrician will doubtless urge against this method of regulation is the multi-

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plicity of dynamos it necessitates. We think, however, that this drawback can be made too much of. Any system of regulation whatsoever means complication, and while in the Lahmeyer system we have indeed additional dynamos, we effect a saving in copper, attain a smooth automatic working, and lessen the duties of the attendants at the Central Station. If modern steam engines, fitted with modern governors, and modern constant-potential dynamos were employed, the only concern of the engineer in charge would be to maintain a good head of steam. There would be no necessity to keep a constant watch on the voltmeter, and to make perpetual alterations in the resistance of the feeders.

At the meeting of the Electrical Section of the London Chamber of Commerce held yesterday (Thursday) afternoon the attendance was rather large, and amusement was caused by the discovery of the fact that the Chairman had intended to hold a committee meeting, and that the notice calling a meeting of the Section had been issued under a misapprehension. It was only last week that we referred to the desirability of holding a sectional meeting, and we do not think that any harm was done by the abandonment of the committee meeting, especially since the Section set to work upon the very same agenda paper. The first question discussed was the formation of a committee to consult with the Committee of the Electrical Engineers on the question of an electrical standardising laboratory. On this committee the following gentlemen were appointed:—The Earl of Crawford, Major Flood-Page, Messrs. Garcke, Goolden, Pell, Swinburne and Wharton. On the question of Railway Rates, the Secretary announced that the Board of Trade proposed to hear the objections raised by each trade separately. After that they would arrange an informal meeting between the Railway Companies and the representatives of the trades, at which probably some points might be amicably settled. Finally, the Board would adjudicate upon the outstanding differences. On this important committee Messrs. Allbright, Garcke and Goolden were elected to serve, with full power to act or to co-operate with other Committees of the Chamber. It was also decided to appoint the whole of the General Committee, with power to add to their number, as a Vigilance Committee, "to watch the proceedings of the Board of Trade, Local Authorities, and other bodies in so far as they affect the Electrical Industry." Considering that the Board of Trade inquiry commences on Wednesday next, this Committee will have some work cut out for it at once.

The extent to which the coding of cablegrams has been carried is strikingly illustrated by a statement made at the Direct Spanish Telegraph Company's general meeting on Monday last. The Chairman informed the shareholders of this company that although they had carried 2,000 more messages in the last three months than in the corresponding period of the previous year they had earned less money; the total number of words transmitted being greatly diminished, notwithstanding the large increase in the number of telegrams. In point of fact there is going on a steady decrease in the average length of messages over all the great cables of the world, and in many cases the process results in a dead loss to the companies. The question is becoming a serious one for them, and hopes are beginning to be entertained that some remedy may be submitted for discussion at the next Telegraph Conference.

With regard to the transfer of the Submarine Telegraph Company's cables to State control, upon which we have commented at length in our leading columns this week, we may congratulate the shareholders on having given their directors a free hand to make the best bargain they can rather than having at once rejected or accepted the offer submitted to them. A little delay will do no harm, and may probably demonstrate even to the French Government that cables which are capable of earning their purchase-money in the course of twelve months are well worth having at that price. What is proposed at present is equivalent to only six months' purchase, and is from every point of view a harsh and unjustifiable attempt to take advantage of the Company's defenceless position.

Mr. Langdon-Davies' "phonopore"—the name is not a happy one—was first heard of some two years ago, when a few experiments were made upon the telegraph line of the South-Eastern Railway. At that time the apparatus had scarcely emerged from the laboratory stage, and although the experiments fulfilled their immediate purpose, the invention has not been again brought into notice until within the last few days. Those, however, who were cognisant of the nature of Mr. Langdon-Davies' discovery—for that is the proper word—were convinced that it contained the elements not merely of a striking advance in multiplex telegraphy, but that it would also in all probability lead up to other scientific and practical uses scarcely as yet foreseen. During the last two years Mr. Langdon-Davies has been hard at work perfecting and developing the apparatus, and so far as regards its application to multiplex telegraphy he has now attained results which may be fitly described as of a highly remarkable character. Next week we hope to publish a fully illustrated description of the device and of its application to duplex and multiplex telegraphy as now being carried out on the Midland Railway Company's lines; but, meanwhile, those who are not acquainted with the principle of the phonopore will probably be interested in the following brief description of the instrument.

The "phonopore" itself consists of an induction coil having two separately insulated secondary wires wound side by side. It is, however, essentially different from an ordinary induction coil, in that there is no circuit through either of the secondary wires, each being terminated, so to speak "in the air." In reality the two secondary coils are situated towards one another like the plates of a condenser. Moreover, the open ends of the two coils are not side by side, one being at one end of the coil and the other at the other. It will thus be seen that the phonopore possesses no conductive electric circuit, but that at the same time its two coils possess coefficients of self and mutual induction combined with static capacity. In what manner this little apparatus lends itself to the purposes of multiplex telegraphy we shall try to make clear next week. Meanwhile, we may remark that the exact nature of its action

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affords very much food for reflection, and will in all probability give rise to a good deal of discussion. As to the mathematical theory, it is no doubt calculated to rejoice the soul of a THOMSON or a HEAVISIDE; but ordinary people may be excused if they are contented with an approximate idea of the physical character of the action. We are glad to learn that there is a considerable probability that Mr. LANGDON-DAVIES will read a Paper on the subject before the Institution of Electrical Engineers some time during the present year.

MR. WEBSTER'S proposals for the electrolytic treatment of sewage upon a wholesale scale were of so novel and, indeed, startling a character, that it is scarcely surprising if a good deal of scepticism was at first evinced in electrical circles. On Wednesday last, however, we spent some hours at Crossness, where we witnessed experiments both on a laboratory scale and also in the works erected by Mr. WEBSTER, which are capable of dealing with a million gallons of sewage per diem. In another column will be found a full description of these experiments, and we need only add that no one having witnessed them could feel the slightest doubt as to the efficacy of the process. On the other hand, every practical man will at once want to know something about the cost. The question is, however, much more easily asked than answered. The actual working expenses on the small scale now running at Crossness amount to about 13s. per million gallons, and at this price the effluent is delivered in a condition of purity which Sir HENRY ROSCOE considers quite unnecessarily high. But the actual cost of the process in any given case depends on several different factors, such as the normal "richness" of the sewage, the cost of iron and coal, and the degree of purification demanded. Moreover, in comparing it with the cost of any chemical process at present in use, it is desirable to ascertain whether the latter process, as carried out, is effectual. It is certain that in many cases, owing to the comparatively small quantities of chemicals employed, the treatment is very nearly ineffective. We are therefore inclined to take a very hopeful view of the future of this new and important branch of electro-technics. We may add that the total sewage of London amounts to 78 million gallons per day, which at the above rate for working cost amounts to nearly £19,000 per annum. The actual amount now expended for chemicals is very difficult to get at, but we believe it to be far in excess of the above figure.

THE Paris International Exhibition will open its doors in less than six weeks from the present time, and, in spite of the recent inundations, we have good reason to believe that, so far as the electric lighting is concerned, all the arrangements will be completed in good time. It seems probable also that the lighting of the Grand Boulevards and of the Place de l'Opera, for which the Municipality recently voted the funds, will not suffer much delay. On the other hand, it is now scarcely possible that the extensive concessions for the public distribution of electricity which were granted in December last will be sufficiently advanced to make any noteworthy display.

AT the moment of going to press we learn, with sincere regret, that Mr. C. H. B. PATEY, C.B., Secretary for Postal Telegraphs, G.P.O., died yesterday (Thursday), at 5 p.m., of congestion of the lungs.

The Elieson Sale.—We have received from Messrs. Wheatley Kirk, Price and Goulty the catalogue of this sale, but defer our remarks thereon to our next issue.

The Board of Trade Inquiry.—It was resolved at the last meeting of the St. Martin's-in-the-Fields Vestry that the clerk should appear at the Board of Trade inquiry on behalf of the Vestry.

Cable to Morocco.—Advices from Tangier report that the Sultan of Morocco has returned a satisfactory reply to the demands of the British Government. The cable is to be repaired without hindrance when necessary.

Lead-Covered Cables.—Writing on this subject Mr. Thomas Connolly says: "From long practical experience and from information received I am prepared to believe all that Mr. Preece asserts in regard to the life of lead-covered cables."

Telegraphic Communication with Bermuda.—In the House of Commons on the 21st inst., in reply to Sir Edward Watkin, the Postmaster-General stated that the Government had decided to lay a cable between Halifax and Bermuda.

United Telephone Company v. New Telephone Company.—We understand that a writ has been served upon the New Telephone Company by the United Telephone Company, and that the case may be expected shortly to come before the Court.

Alternate Cable Route to South Africa.—The Telegraph Construction and Maintenance Company's s.s. "Scotia," with the cable on board for the southern sections of the alternate cable *vid* the West Coast of Africa to the Cape of Good Hope, arrived some days ago at Cape Town.

Societe Internationale des Electriciens—The annual meeting of this society will take place on Wednesday next, when the Comité d'Administration for this year will be elected. The proposed president is Colonel H. Sebert, the vice-presidents being MM. Cornu, Hippolyte Fontaine and Raymond.

Conference on International Patent Law.—A committee appointed by Lord Salisbury is sitting at the House of Commons to consider the action of the British Delegates at the forthcoming Conference at Madrid, which is to settle a new International Convention with regard to patents. Mr. Shipton was the chief witness examined.

Instruments for the Measurement of Radiant Heat.—Mr. Vernon Boys is now delivering an interesting course of Cantor Lectures before the Society of Arts on this subject. The lecture on Monday next will be of special interest to electricians, as it will treat of thermo-piles, d'Arsonval's thermo-galvanometer, and other electrical instruments.

Royal Meteorological Society's Exhibition.—The annual exhibition of this society was held at the rooms of the Institution of Civil Engineers last week. The exhibition was chiefly devoted to actinometers and solar radiation apparatus, but it also included an interesting collection of photographs of lightning. There did not, however, appear to be any special features disclosed in these particular photographs that had not already been observed.

Portraits of Cable Celebrities.—Messrs. W. H. Beynon, fine art publishers, of St. Alban's Lodge, Cheltenham, have just issued (for private circulation) two remarkably good portraits of Viscount Monk, chairman of the Anglo-American Telegraph Company, and of Mr. Thomas Fuller, managing director of the Brazilian Submarine Telegraph Company. These are companion pictures to those of Sir John Pender and Sir James Anderson, issued by the same firm.

Galway.—The Galway Harbour Commissioners have decided, by a majority of ten to five, to adopt the electric light for harbour purposes. The tender of the Galway Electric Company, to supply 1,000 candle-power arcs at £20 per annum, and incandescents, ranging from 16 candle-power to 100 candle-power, at prices ranging from £1. 19s. 6d. to £5. 10s., has

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been accepted. The works of the Galway Electric Company are in close proximity to the docks, and the dynamos will be driven by water-power.

Printing by Electricity.—On Saturday evening last the *Star of the East* was printed at the office of the *East Anglian Times* entirely by electricity, current being obtained from storage cells at Messrs. Laurence, Paris and Scott's electrical work in Carr-street, and the dynamo usually employed in lighting the building being run as a motor. The experiment, we believe, is the first of the kind in the kingdom, and was entirely successful. The credit of the performance belongs to Messrs. Laurence, Paris and Scott, and to their Ipswich manager, Mr. Sisling.

St. Olave's District Board.—At a meeting of this Board last week, the question of electric lighting of the district was considered. The Clerk said he had made certain objections to the proposals of the London Electric Supply Corporation, and the company now suggested that the Board should give their assent subject to the Board of Trade considering the matter. The Board resolved to accord their sanction to the scheme of the London Electric Supply Corporation, subject to the forms of order issued by the Board of Trade after that authority had heard the objections.

Nottingham.—The special committee appointed by the Nottingham Town Council is now considering the application of the Nottingham Electric Light and Power Company for the concession of an electric lighting area. At present no report has been agreed to, but an intimation has been given to several electric lighting companies that the application in question has been made to the Council, and these companies have been asked whether they are disposed to make any offer, if so, on what terms; and, further, whether they will insist upon the forty-two years of the purchase clause contained in the Electric Lighting Act of last Session.

Taunton.—It is evident from the following extract from a local paper that the people of Taunton are more than satisfied with the lighting of their town:—"Far from being a failure in Taunton, up to the present time the electric light has been a brilliant success, and the ratepayers, we feel sure, would be very reluctant to part with it. The light has been steady, strong and reliable. The demand for it is extending, and the prevailing desire now is that the company may find themselves able to apply it to domestic purposes." Taunton has recently been visited by deputations from the Bedford and Chelmsford Town Councils for the purpose of inspecting the electric lighting arrangements.

The Society of Arts Motor Trials.—At the Society of Arts last Wednesday week Prof. Kennedy, F.R.S., read a Paper relating to the recent motor trials instituted by the Society, explaining their object and the methods adopted, in language suited to a non-technical audience. The thoroughness and trustworthiness of the trials were afterwards testified to by Sir F. Abel, C.B., and Mr. W. Anderson, M.I.C.E.; the Chairman, the Duke of Abercorn, then presenting the Society's gold medals to the following competing firms:—The British Gas Engine and Engineering Company for a 6 horse-power Atkinson "Cycle" gas engine; Messrs. Crossley Bros. (Limited), for a 9 horse-power "Otto" gas engine; Messrs. Dick, Kerr and Co., for an 8 horse-power "Griffin" gas engine; Messrs. Davey, Paxman and Co., for an 8 horse-power compound portable steam engine.

Chelmsford.—As reported in our last issue, the Chelmsford Town Council recently held a special meeting to consider the question of the public lighting of Chelmsford, and it was decided, amongst other things, to call a public meeting, and invite the opinion of the burgesses upon the matter. This meeting took place in the Corn Exchange on Tuesday evening last, and there was a large attendance. Mr. Councillor Whitmore moved "That this meeting is of opinion that the recommendation of the Lighting Committee be carried out, namely, that the Council be requested to accept the tender of Messrs. Crompton and Co. for the public lighting of the borough." Mr. Alderman Duffield, chairman of the Gas Company, said the Gas Company had sent in an amended tender, offering to light all the present lamps for the sum of £604, which was something like £100 in excess below the tender of Messrs. Crompton and Co., and asserted that the electric light for public purposes had proved almost an entire failure. Mr. Councillor Whitmore's proposition was then put and carried by a very large majority.

Proposed Spanish-Cuban Telegraph.—Barcelona advices report the existence of a movement in that city for the establishment of a cable between Spain and the Spanish Antilles. The commercial association in Barcelona known as the *Fomento de la Produccion Española* has petitioned the Colonial Minister in favour of the scheme, and it is stated that, provided the sanction of the Government can be obtained, local capitalists are prepared to form a company to carry the proposal into effect. It is pointed out that a direct cable not touching at any foreign port would be advantageous to the State, and its feasibility is urged upon the grounds that there is already a cable from Cadiz to the Canary Islands, a distance of 720 miles, and from Cienfuegos to Santiago in Cuba. It would only, therefore, be necessary to lay a cable from the Canary Isles to Porto Rico, a distance of 2,700 miles, and from Porto Rico to Santiago de Cuba, a distance of 100 miles.

Reading.—For some weeks past preparations have been made by Messrs. Laing, Wharton and Down, with the consent of the Corporation, for the installation of their electric lighting system in Reading for a month's trial, and a preliminary trial of the lights was recently made with considerable success. The central station is situate on what is known as the Island, in Duke-street. The engine-room plant is in duplicate throughout, and comprises two engines of 10 horse-power nominal, running at 380 revolutions per minute, with steam at 110lbs. Each engine drives direct a Thomson-Houston H type dynamo, running at 950 revolutions per minute, and capable of supplying eighteen 1,200 candle-power arc lamps on a five-mile circuit. The boiler is a Babcock and Wilcox 25 horse-power water tube boiler. Messrs. Laing, Wharton and Down are ready to supply thirty 1,200 candle-power arcs for street lighting at £22 per lamp per annum.

Telegraphic Charges to Austria.—According to the Vienna correspondent of the *Standard*, while the telegraphic charges between Germany and England are to be reduced after 1st of April, the rates between England and Austria are to be maintained at their old level. The reason assigned is that Germany refuses to allow Austro-English correspondence to profit by the new tariff. Ten words to England from Vienna cost at present two florins thirty kreutzers, while the charge to Germany is seventy kreutzers, and from Germany to England ninety kreutzers. Consequently a saving of seventy kreutzers, or thirty per cent. can be effected by telegraphing to Germany and thence to England, instead of direct. The fact is so injurious to trade between Austria and England, that the English Postmaster-General would do well to bring some pressure to bear upon the German Postal Administration, in which step he would be readily supported from the Austrian side.

Entertainment at the Edison and Swan Company's Factory, Ponder's End.—The second annual concert was held at the company's works, Ponder's End, on Wednesday evening, 27th inst. Nearly the whole of the *employés* availed themselves of the kind invitation of Major Flood Page (Secretary) and Mr. Gimingham (Resident Superintendent). A few tickets for friends had been issued, and the number present would probably be about 500. Before the concert commenced Major Flood Page addressed a few words of welcome couched in very appropriate terms. Regarding it from any standpoint, the entertainment was a complete success. A good programme was provided, the songs, &c., of the ladies and gentlemen who volunteered their services being much appreciated. Mrs. Gimingham and Miss Goater accompanied the singers. A sketch entitled "A Curious Dilemma" was very ably rendered by a few of the *employés*. The programmes were tastefully got up for the occasion, a striking and pleasing feature being a series of unique designs by Mr. Watson, bringing into prominence the company's manufactures, such as incandescent lamps, fittings and miners' safety lamps. The large room in which the company assembled was decorated with flags and lighted throughout with coloured electric lamps. A drop scene painted by Mr. Watson was very much admired. The whole of the arrangements were under the direction of Mr. Robson.

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Telegraphic Communication with Johannesberg. — The following is extracted from the *Natal Mercury* of February 27th last:—"The need of activity is undoubtedly pressing in the case of the telegraphic service, which has again and again broken down of late under the weight of abnormal correspondence. No one could possibly foresee that Johannesburg would become the telegraphic focus of South Africa. Thither flock the messages of the speculating world. The Rand is for the moment the Mecca of the London Stock Exchange. It is not less the goal of every South African 'operator.' Facilities of communication with Johannesburg just now mean gain or loss—fortune or failure—to thousands and tens of thousands of persons. Priority of knowledge is a matter of transcendent concern to people who have thousands dependent upon the chances of a rise or fall in the share market. The deliberate cutting down of hundreds of yards of wire between Coldstream and Heidelberg shows to what lengths roguery will go. When we write, telegraphic communication with the Rand has been suspended for four days. Before this issue appears it may have been resumed, but no one can say what gains or what losses may not have occurred through this suspension. That the gains have been fraudulent in so far as they have accrued to those who planned and executed the breakage of the wire goes without saying; but many operators perfectly innocent of complicity in that crime will have benefited or suffered by the fact. It is so easy to bring about a stoppage of this sort that specially remedial measures are unavoidable."

Barnet.—At a recent meeting of the Barnet Local Board the subject of the position of the contractor for the electric lighting of the town, in view of the circular issued by the Board of Trade early last month, was under consideration. A report was read from the Lighting Committee, stating that they had discussed the terms of the Board of Trade circular, and had come to the conclusion that, in the face of this communication, the Board could not allow the streets to be interfered with by the electric light contractor until the statutory powers referred to therein had been obtained. At a meeting held on the 18th inst. the contractor attended before the committee and urged the importance to him of the transfer of his liability under the existing contract to the proposed company. The Committee, however, pointed out that after the receipt of the communication from the Board of Trade they could not recommend such a course to the Local Board until proper powers had been obtained by the contractor, as stipulated for in the contract. The report was adopted. At a subsequent stage of the proceedings letters were received from Mr. Joel's solicitors asking that the Board would join with the contractor in a memorial to the Board of Trade, praying them to waive the month's notice required for the special meeting of the Local Board to give their consent to an application to the Board of Trade. After some discussion it was resolved "That a reply embodying the facts of the case as now before the Local Board be sent to the Board of Trade, and that in the letter it should be shown that the Local Board are desirous of complying with its duties under the contract, and particularly with the rules of the Board of Trade," the Chairman remarking that in this way the Board could assist the contractor without committing themselves in any way.

The Tangiers Cable.—The following extracts from the *Times of Morocco*, of the 16th inst., will give some idea of the state of affairs at the Ports of Morocco:—"Some idea of the ridiculous scare which at present prevails in Morocco, raised by the refusal of the Customs Administrators at Tangiers to pass a length of wire required by the Eastern Telegraph Company to repair their line at this end may be gathered from the following extracts from letters received:—A Mogador correspondent states that 'A scare was raised on 1st March among the native population by the summoning in hot haste of the troops, both *gaïsh* and *âskar*, and their being told off to man the forts of the town and the two islands, other parties being dispatched to occupy the village of Decâbat, and patrol the beach on either side of the town, with orders, if they saw anything approaching from the sea, to fire without mercy.' All that could at first be gathered of the cause of this unwonted activity was that Shereefian orders had been received by the authorities to be 'on the look out.' Needless to say the wildest rumours were current among the more ignorant native, not a few rushing to the conclusion that there was to be an immediate war with the Christians, nation not specified. Others in mysterious whispers hoped the Sultan was in good health. Meanwhile the martial preparations went briskly on. Gunpowder was served out to the troops, and many were the rusty old guns unearthed and placed in the hands of boys who had never discharged a musket in their lives. An informal sort of parade was held by the *Kâ'id*, before whom these gallant, involuntary recruits were required, one after the other, to fire off their weapons. Those who bungled very badly 'ate stick.' All night long bullet-moulds were at work. On the 2nd inst. it leaked out that these measures were taken with the view of preventing a telegraphic cable being laid by some foreign company, and the arrival of the ss. 'Les Vosges,' with news from Tangier, confirmed this view of the matter." Another Mogador correspondent writes:—"The rumour spread that the Spaniards were coming; of course the Mellah was in a fearful state by Sunday; yesterday the story was that they were watching for someone coming to lay a cable. One of the soldiers' description of his orders are immensely amusing. When asked what he was doing on the battery wall he said, 'The Governor told me I was to look up and out to sea, and if I saw a great ball coming down from the skies towards the shore dragging after it a long wire, I was to fire at it.' It is evidently a telegraph scare, and probably only got up on account of that 30 miles of wire lying at Tangier now."

Electric Lighting in London.—The Board of Trade has addressed the following letter to the Earl of Rosebery as Chairman of the London County Council:—

"Board of Trade (Railway Department),
"London, S.W., 13th March, 1889.

"My Lord: I am desired by the President of the Board of Trade to inform your lordship that the question of Electric Lighting in the Metropolis is at present receiving the serious consideration of this Department. Thirteen applications for Provisional Orders, under the provisions of the Electric Lighting Acts, 1882 and 1888, in respect of areas within the metropolis, are now before the Board.

"In dealing with these applications the Board of Trade are at once confronted with two important questions of principle:—

"(1) What should be the extent and nature of the area to be granted?

"(2) Should, or should not, concurrent powers be granted to two or more companies within the same area?

"As regards the former, many considerations must be taken into account—*e.g.*, what is the financial position of the undertakers applying for statutory powers in any given area; how far any one company would be in a position satisfactorily to supply such an area, and in connection with this much would depend on what distance electrical energy for electric lighting purposes can be safely and conveniently furnished from a central station.

"As regards the latter question, on the one hand it appears to the Board of Trade to be highly desirable to avoid the grave inconvenience to which the public were subjected when there were competing gas companies supplying the same areas in the metropolis; and, further, in the case of electric lighting, that uncertainty exists whether mains can be satisfactorily laid in close proximity to each other. On the other hand, some of the Local Authorities in the Metropolis appear to be desirous to encourage competition, and are anxious to avoid the creation of a monopoly or quasi-monopoly for electric lighting by giving any company exclusive powers for any one area.

"Before deciding on the action to be taken on the applications at present before the Board of Trade, they propose to adopt their usual procedure, and to hold a local inquiry, of which full notice will be given, and at which all those interested can be heard; but they are anxious to take no definite step which may have important bearing on the future policy to be pursued with regard to Electric Lighting in the Metropolis without communicating in the fullest manner with the County Council of London.

"In this determination they are greatly influenced by the consideration that before long the jurisdiction which the Board of Trade now exercise in regard to electric lighting matters in the metropolis may be transferred to the County Council, and they would therefore be most unwilling to take any action which might hamper that body in dealing with the question in the future.

"With this view they propose, as soon as the report of the inquiry has been received, to forward it to your lordship for the information of the County Council, and I am, at the same time, to express a hope that this Board may then be favoured with any observations which the County Council might wish to offer upon this large and very important question.—I have, sir,

"The Earl of Rosebery." (Signed) "HENRY G. CALCRAFT.

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NOTE ON THE BURSTING OF LEYDEN JARS.

BY DR. OLIVER LODGE.

The circumstances attending the electrical fracture of Leyden jars are of some interest. So far as my experience goes, they do not often burst by being merely overcharged to too high a potential—whether they ever do so I am not sure—but they burst at the instant of discharge by the recoil and oscillations set up in the discharging circuit. When this discharging circuit is a long one I should have expected their fracture to be more probable, were it not that they then readily overflow. A spark of an inch or less will easily make a jar spark over its edge if it be joined up to a suitable wire circuit, and this ease of overflow may perhaps save them from breaking.

With a short discharge circuit it may be possible to take sparks several inches long without their overflowing, and the question is whether they are then more liable to burst or not. In other words, are bursting and overflowing the same thing? Fortunately my jars, though they frequently overflow, scarcely ever burst, and accordingly my experience is too limited to be any use.

When I take very long sparks from jars I use two in series; their liability to overflow is then greatly diminished. This is no doubt the empirical reason of the pair of jars used in all forms of inductive machine.

Apropos of the bursting of jars I have permission from the writers of the two following letters to communicate them, and I also quote a statement by Franklin on the same subject:—

Answer by Dr. Franklin to a question put by Dr. Ingerhouse about 1777.

"By the circumstances that have appeared to me, in all the jars that I have seen perforated at the time of their explosion, I have imagined that the charge did not pass by those perforations. Several single jars that have broken while I was charging them have shown, besides the perforation in the body, a trace on both sides of the neck where the polish of the glass was taken off the breadth of a straw, which proved that great part at least of the charge, probably all, had passed over that trace. I was once present at the discharge of a battery containing thirty jars, of which eight were perforated and spoilt at the time of the discharge; yet the effect of the charge on the bodies upon which it was intended to operate did not appear to be diminished. Another time I was present when twelve out of twenty jars were broken at the time of the discharge, yet the effect of the charge which passed in the regular circuit was the same as it would have been if they had remained whole.

"Were those perforations an effect of the charge within the jar forcing itself through the glass to get at the outside, other difficulties would arise and demand explanation. 1. How it happens that in eight bottles, and in twelve, the strength to bear a strong charge should be so equal that no one of them would break before the rest, and thereby save his fellows, but all should burst at the same instant. 2. How it happens that they bear the force of the great charge till the instant that an easier means of discharge is offered them, which they make use of, and yet the fluid breaks through at the same time."—(Franklin's Works, Ed. Sparks, Vol. V., p. 462.)

The following two letters from Mr. Boys and from Mr. Bottomley tell their own tale:—

"It may interest you to hear how some of the large Polytechnic jars were broken here when we tried the 7ft. Wimshurst machine on them.

"On connecting up 1, 2, 3, or 4 'for quantity,' or in pairs 'for intensity,' with the machine, and charging until the brush discharge from the conductors was such as to make further increase of potential unattainable, and then causing the knobs to approach one another, there used to be a deafening explosion when they were from 12 to 16 inches apart, and almost every time one (or more?) jars were found shattered in one or more places. At each place of rupture the centre portions of the glass were white, being completely pulverised. This part would be a $\frac{1}{4}$ inch or so in diameter. Outside this radiating but irregular cracks spread in all directions over a space of two inches or so, and these cracks were joined by other cracks, more especially near the central powder.

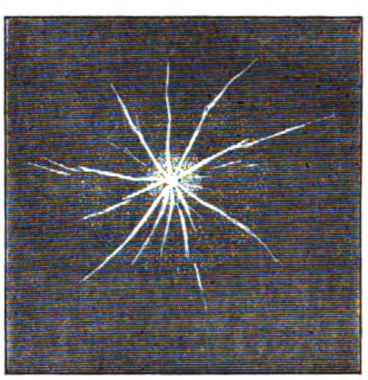
"This never happened during the charge, but only when the discharge was made at the knobs, and no doubt was largely due to electric oscillations breaking down the glass, which, while it could stand the steady pull one way, could not resist the see-saw. This may, for anything I know, have synchronised with the natural period of vibration of a bar of glass as long as the jar was thick where it broke.

"Finding that the proceedings seemed destructive of jars we left off.—Yours, &c., "C. V. Boys."

"13, University-gardens, Glasgow, March 22, 1889.

"The experiments, of which I wrote to you very hurriedly on February 6th, were made with a very large influence machine which my friend Sir Archibald Campbell, of Blythswood, has been building. I will tell you something more about the machine a little later; but meantime, in a very imperfect state—indeed almost at first trial—we got $\frac{1}{8}$ of a milliampere from it, as measured by decomposition of water. I have no doubt we can get a great deal more when we know the conditions necessary for keeping the potential of the parts which act as inductors from falling away as we draw off current.

"While the machine was giving a spark of $5\frac{1}{2}$ or 6 inches we sparked through two very large jars, 12in. high by 7in. in diameter, the glass about $\frac{1}{8}$ to $\frac{3}{16}$ thick, tinfoil 9in. up. On examining them it turned out in each case that the jar had been perforated in many places. In one jar there are six or seven holes, in the other I can count thirteen. The tinfoil was blown outward *on both sides* in each jar in six or seven places. It stood up from the glass in little protuberances bigger than a split pea, and in many cases, at any rate, the summit of the protuberance is pierced. On removing the tinfoil the glass showed unmistakable signs of many holes arranged in a line (in the case of the jar with the largest number of holes in two lines, one branching off from the other). The holes are about half an inch apart; the distances tolerably regular. There is in one of the jars one very heavily pulverised place and two in the other;—round spots about a quarter of an inch in diameter,



where the glass is a mass of white powder, in each case at one end of the line of holes and seemingly a starting place; and in the very centre of the most thoroughly pulverised spot there is a small clean round hole, through which I can put a wire one-hundredth of an inch in diameter right through, quite loosely and without rubbing on the sides of the hole. (I have not tried the largest wire possible as I do not want to disturb the glass powder just yet.) The remaining holes are small perforations, a crack joining them all, and round about each there is a small spot covered with metal driven off the tinfoil on to the glass.

"One of the sets of perforations is just round the upper edge of the tinfoil coatings. The other is round the bottom of the jar.

"I shall be greatly interested to see what you say about the matter, and when we break any more—which I doubt not will be soon—you shall hear of it.—Yours, &c., "J. T. Bottomley."

Note added by Mr. Boys.

The first of Mr. Bottomley's letter reminds me that the position of the holes in the glass was indicated by large blisters in the tinfoil and that in the centre of the white powder there was, as he describes, a clean hole. The glass in these jars was not, as far as I can remember, as much as $\frac{1}{8}$ inch in thickness at the places where they broke. C. V. B.

ELECTRIC LIGHTING AT THE ERECTION OF THE FORTH BRIDGE.

BY ALFRED E. MAYOR.

As the Forth Bridge is now approaching completion, a description of the lighting arrangements, which have in some measure facilitated its rapid progress, may be of some interest at this time. From the beginning operations have been carried

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on continuously day and night, and among the earliest of the preliminaries was the arrangement of electric lighting installations. Messrs. Siemens Bros. secured the contracts for lighting the offices, machine shops, yards, and jetties on the south side of the river, while Messrs. Crompton and Company secured the smaller contracts on Inch Garvie and North Queensferry. During the foundation work electric lighting was extensively used, not only on the stagings and jetties but in the working chambers of the caissons, where they proved invaluable aids to the men, who were working under the most trying conditions in an atmosphere of from 30 to 45lbs per square inch pressure. Arc lamps of the ordinary Siemens differential type were used: they had triple carbons, and of course these were consumed with great rapidity, and had to be frequently renewed. The divers working on the exterior of the caissons used incandescent lamps with strong protecting glasses, and these within a limited radius proved of great service. On the completion of the foundations and commencement of the superstructure a complete re-arrangement of all the lighting plant became necessary to meet the widely different requirements.

The installations as remodelled and extended may be briefly described as follows:—On the south side of the river, for the lighting of the engineering shops and yards, which cover an area of 50 acres, there are three Siemens SD^9 dynamos, each supplying 120 amperes at 110 volts, one Crompton and one Siemens machine, each supplying 50 amperes at same E.M.F., and five Siemens SD^8 machines for series arc lighting, each with a current of 15 amperes and 300 volts; there is also a Crompton machine for the same purpose wound for 15 amperes at 1,200 volts. Horizontal high-pressure coupled engines, indicating 120 horse-power, by Messrs. Davy, Paxman and Co., of Colchester, drive seven of the above dynamos, and two smaller engines, indicating respectively 30 and 10 horse-power, drive separate incandescent lighting dynamos. At the Central Pier, on Inch Garvie, there are two Crompton-Burgin dynamos, each for six arcs in series, and two 60-light incandescent machines of same type. These are driven by a pair of Shanks Caledonian engines, and there is a separate arc lighting plant, with a dynamo by Crompton, wound for 15 amperes at 1,200 volts, and driven by coupled Gwynne engines. On the north side of the river there are two Crompton machines, each for 80 incandescent lamps, and two Burgin machines, each running 12 arcs in series. These are driven by a 60 horse-power horizontal engine, and there is a separate plant for 24 arcs, similar to that on Inch Garvie. Underground conductors had been extensively used in the South Installation: they consisted of cables insulated with gutta percha and jute, with a sheathing of steel wires and an external serving of jute and compound; after three years' use they had all become more or less defective; they were, therefore, raised and removed to the erection, where their metallic covering is of great service, and when the demands of insulation are not so high, owing to the possibility of running them almost continuously on timber stagings. The machine shops are lit by Siemens differential lamps, principally arranged in parallel circuits of two lamps in each. Distributed among the cantilevers are 100 Crompton D D lamps. These have worked very satisfactorily under the most trying conditions.

The plan adopted for wiring the erection is as follows:—Overhead wires are run from the dynamo stations to distributing boxes at the different piers, and flexible cables tied to ropes are led from these to the lofty stagings on the structure. The lamps are suspended from light poles lashed to the girders, or are swung direct between guide wires from the arc bracings. Groups of lamps in series with other groups provided with automatic cut-outs and equivalent resistances to isolate the effects of accidents to the conductors. All the arrangements are necessarily extremely portable, as the stagings are constantly being shifted and re-arranged with the progress of the work. Although arc lighting has been extensively used at these works, and the advantages of its portability and cleanliness fully appreciated, its numerous disadvantages have also been amply demonstrated. In the engineering shops, in which the steel is prepared by numerous planing, drilling, and bending machines, the arcs have required the aid of myriads of hand lamps to render nightwork possible, and this notwithstanding the utmost attention which has been bestowed on the distribution of the light. In the erection of the steel the drawbacks of arc lighting have been even more conspicuous. Light temporary stagings, where even in daylight men must move about with much care, are in many cases lit up by an arc at some little distance off, but if even a small object is interposed between them and the minute source of light the men in their perilous positions are instantly thrown into extreme darkness by the sharp intense shadow. The works have therefore been a fitting place for the trial of rival means of illumination, and these have been forthcoming in considerable abundance, the most prominent among them being the Lucigen, which had one of its earliest and most extensive applications at the Forth Bridge. This light is probably familiar to most of the readers of *The Electrician*; it is obtained by forcing creosote oil or other heavy hydro-carbons, in the form of a spray, through a small nozzle by means of air pressure. The flame is about 3ft. long, and emits a light of great intensity and diffusive power. To maintain air pressure for each light of 2,500 candle-power only ·25 horse-power is necessary. When first introduced the oil—a bye-product in the manufacture of ammonia gas—was extremely cheap, and it seemed as if the new light was going to carry everything before it, but, although for many purposes it is unquestionably superior to the arc, it has not been completely successful, and more mature experience tends to considerably restrict its sphere. Its only unqualified advantage is its extreme diffusive power, and against this must be placed numerous defects which greatly modify its utility and convenience. Its alleged economy as compared with all other means of artificial illumination is quite fallacious. Creosote oil costs just now about 3d. per gallon undelivered, and, of course, the cost of transport is considerable; to maintain a light of 2,500 candle-power the lamp consumes from 2¼ to 3 gallons of oil per hour, according to the quality of the oil; considerable allowance must also be made for waste. A fair estimate of the cost per lamp of 2,500 candle-power is 9½d. to 10d. per hour. A small quantity of water in the oil instantly extinguishes the lamp, and one source of trouble with the system is the almost unavoidable presence of water in the oil; this water must be filtered away and carefully conducted to the sewers, as it is a product of intense annoyance. The light requires considerable attention, and is very unsatisfactory in a wind, as it is liable to go out, when the unconsumed oil is blown over the timber stagings, greatly increasing the risks of fire. Thus, notwithstanding the superior diffusive power of the Lucigen, the arc has maintained its position on all the elevated stagings, the Lucigen being extensively used, however, for the illumination of the yards and lower portions of the structure. It is, of course, misleading to estimate the power of such lights as the Lucigen by the ordinary photometric standard, as 1,000 candle-power from such incandescent lamps as those of the Sunbeam Company is much more effective than 2,500 candle-power from the Lucigen; this is doubtless owing to the perfect steadiness of the rays from the former. Sunbeam lamps are extensively used here, and are much preferred to either the arc or Lucigen; the additional cost is in many instances amply compensated by overwhelming advantages. There is, of course, a wide field for all classes of lights in a work of such magnitude, and the special adaptability of each has been as far as possible utilised. The spectacle presented on dark nights when the bridge is illuminated is a very striking one. The coronas of brilliant lights, from their lofty positions on the great structure, cast beautiful reflections into the water, and the massive overhanging columns and girders look most imposing when they are seen out of the darkness. It is expected that the last rivet will be closed in the autumn of this year, and already the electrical installations are being dismantled and prepared for the market. The dynamos have worked most satisfactorily throughout, and when it is remembered that these machines are of an early pattern, and have passed through rather a trying ordeal, the fact that they are now practically as good as new reflects the highest credit on their makers, Messrs. Siemens and Crompton.

Office Lighting.—The electric light is being put into the offices of Messrs. Rothschild in New-court, London, E.C.

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MR. WEBSTER'S ELECTROLYTIC METHOD OF SEWAGE PURIFICATION.

The problem involved in the disposal of the sewage of our large towns is one not only of the utmost importance, but also of increasing magnitude and complexity; and, moreover, the conditions under which it must be dealt with vary greatly in different localities. So long ago as the year 1762 proposals were made for the artificial purification of sewage before discharging into running water, and since that time innumerable inventors have attempted the solution of the problem; but though more than one chemical process is to be found in operation, it is an admitted fact that hitherto no very substantial success has been attained.

The electrolytic process was first suggested by Mr. W. Webster some two years ago, and it is only fair to state that at that time he already possessed an adequate knowledge of the chemical methods hitherto proposed, and, moreover, he had had exceptional opportunities for observing the actual operation of these processes. In the autumn of last year Mr. Webster read a Paper upon the subject before the Society of Municipal and Sanitary Engineers, which appeared in *The Electrician* of September 7th, 1888, p. 558. Many of our readers will, therefore, be already acquainted with the main features of the electrolytic process. The actual operation is simplicity itself, although the electrolytic and chemical reactions are undoubtedly somewhat complicated; in fact, although only one operation is performed, there are really two results, one mechanical and the other chemical, as we shall presently explain. On Wednesday last, when the representatives of the technical journals visited the Outfall Works of the Metropolitan Sewerage System at Crossness, where Mr. Webster has now had an experimental plant in operation for the last nine months, we first witnessed some laboratory experiments upon a small scale designed to show the principle of the method. The colour, density, and constitution of the London sewage varies from hour to hour in a most extraordinary manner, but the first sample to be dealt with was of a light yellow colour, looking something like weak tea with a little milk in it; but so far as could be seen it contained very little solid matter in mechanical suspension. This having been poured into a test jar, a current was passed through it between a pair of iron electrodes, with about 6 volts E.M.F. An extremely rapid effect was produced. In less than two minutes the jar was seen to be filled with a flocculent precipitate which was gradually carried upwards by the bubbles of liberated hydrogen. After about three minutes the electrodes were withdrawn, and the precipitate left to collect at the top. In actual practice, after the effluent has passed into the settling tank the precipitate in the course of about two hours loses the whole of the entangled hydrogen; it then sinks to the bottom of the tank. The sludge thus formed is similar to that produced by the chemical processes now in vogue, except that the electrical method possesses the obvious advantage that the total quantity of material has not been increased by the addition of chemicals.

This removal of the precipitated solids, although it is the only effect visible to the eye, does not constitute the whole of the operation, nor even its most important part. There is also a chemical action upon the organic matters in solution, the exact nature of which is not wholly understood. It has long been known, however, that many of the ferrous salts, and the green ferrous oxide in particular, possess the property of acting upon or combining with organic matter in solution, although the chemical formula cannot at present be written down. Mr. Webster is inclined to think that in this instance the first step in the process consists in the formation of a hypochlorite of iron. All sewage, particularly in the absence of rainfall, is rich in chlorides, and this fact, it may be remarked in passing, is of advantage in increasing the electrical conductivity of the fluid. In any case, it is a fact that a certain quantity of free chlorine is liberated at one pole (which, of course, itself acts as a deodoriser and disinfectant), and the iron is ultimately converted into the form of the green (ferrous) oxide.

After the first experiment several samples of sewage, one of which was almost black in colour, were treated in the same way, and the flocculent precipitate was in every case produced with great rapidity. It may be added that the process must not be carried too far, otherwise the alkalinity of the effluent is increased to such an extent as to lead to secondary decomposition and the possible formation of sludge in the bed of the river. The consumption of iron has been found to be about two grains per gallon, but this is a quantity which depends upon the extent to which the purification is desired to be carried.

The following notes, describing the actual details of the process as now being carried out at Crossness, have been kindly furnished us by Mr. Webster.

"Since writing my former notes on the above question I have carried out a long and exhaustive series of experiments at my experimental works at Crossness, which have proved beyond doubt that I can produce on a commercial scale results at least equal to those obtained in the laboratory, and probably better. The mode of treatment adopted is the same, with the exception that for the slight

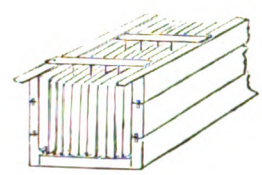

FIG. 1.—Detail of Shoot with Iron Electrodes.

motion of the electrodes, which was found necessary to bring the sewage into intimate contact with the plates, a movement of the liquid to be treated is substituted, the sewage being acted upon as it passes through the electrolytic channels leading from the sewer to the reservoirs or settling tanks.

"Starting with the engine shed, the engines, of an old type, made some 25 years ago, are each 20 horse-power nominal. By the arrangement of gear, one engine only is used at any one time, both for pumping and for driving the dynamo. The dynamo is an Edison-Hopkinson, capable of developing an energy of 43 horse-power. From the dynamo the leads run through resistance frames, by means of which the amount of current can be regulated without varying the speed of the engine. These are then connected with the iron electrodes in both the precipitating tanks and the shoot. The precipitating tanks are used for taking experimental measurements, so as to discover the best mode of arranging the electrodes, hereinafter called plates, made of cast iron, run direct from blast furnaces. Owing to want of space, I found it desirable to fit the shoot (*see* Fig. 1) with wrought-iron plates, which, of course, are

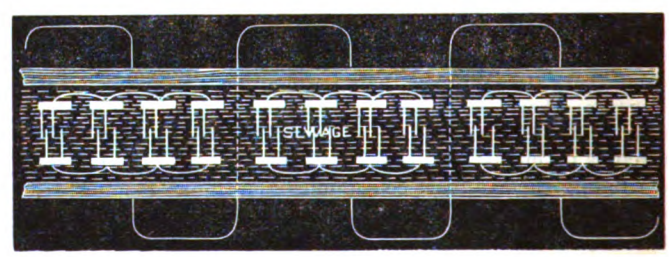

FIG. 2.

more convenient for experimental work, as they are thinner and weigh less than if made of cast iron. The shoot is of wood; but in any permanent work it would be built of bricks, concrete, or iron, and the bottom would be lined with asphalte or other suitable material.

"The sewage is discharged into the shoot from the pump connected with the main sewer. In travelling along the shoot every particle of the sewage comes in contact with the plates, and finally the whole is received into one or other of the settling tanks. All the plates in each section are connected in parallel, and the sections can be connected either in parallel or in series (*see* Fig. 2), as may be most convenient. I find it best in this instance to run them arranged as six sections in series, as, owing to the low tension of the dynamo, it is inconvenient to split them up into a greater number of sections. My experiments prove that with 27 horse-power it is possible to treat one million gallons of sewage in 24 hours. With this statement I must couple the remark that the figures relate to average London sewage.

"As to the cost of the engine power, I need hardly state that the newest type of engines suitable for driving dynamos may be taken to consume two pounds of coal per horse-power hour, and accord-

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ing to the price of the coal will be the working cost. The experiments carried out with reference to the amount of iron consumed by this process tend to prove that the consumption in continuous working should not be more than two grains per gallon. Here again the cost entirely depends upon the position of the works, or more properly speaking, the district in which the works are situated. The prices in the pig iron market are so well known that I need not enlarge on this point. The plates are one inch thick, and if used in sufficient numbers would last for many years when once fixed. For instance, I will take a town with a flow of ten million gallons of sewage per day, corresponding to a population of 330,000, at 30 gallons per head. To treat this amount of sewage, the consumption of iron should not exceed 364 tons per annum, and the steam plant required represents about 8 horse-power per 10,000 inhabitants.

"It will be seen that the above plant is practically in lieu of the mixing tanks, machinery, and chemicals employed in chemical processes for the treatment of sewage, and if such electrical plant is designed to meet the peculiar requirements of any particular district, it must, in my opinion, cost less and have a greater efficiency than any other process known, for not only does this electrical method precipitate the matters in suspension, but it also removes organic matter in solution, and forms a precipitating and disinfecting process in one operation.

"The appended analyses of sewage and effluents show the reduction of both suspended and soluble matters by means of one treatment and also at the smallest possible cost."

ANALYSES OF EXPERIMENTS, 1888-9.

Parts per 100,000.

—	Appearance.	Odour.	Nitrogen as		Chlorine as Chlorides.	Oxygen required to oxydise organic matter.	Suspended matters.
			Free Ammonia.	Albumenoid matter.			
Average of 20 Analyses	Raw Sewage, very turbid & opalescent	Slight	4·34	0·5	21·64	1·24	33·35
	Effluent, clear	None	3·22	0·2	18·62	0·52	1·56

Time of settlement one hour in open reservoirs.

We may add, in conclusion, that the Edison-Hopkinson dynamo is a fine machine, built for the purpose by Mather and Platt, and capable of yielding about 1,600 amperes and 25 volts at 350 revolutions. The current density employed in the shoot is about 1 ampere per 11 square feet of surface, the total current being about 500 amperes. The sewage occupies about 10 minutes in traversing the full length of the shoot, which is about 400 feet in length. The total quantity of electricity employed is at the rate of ·25 ampere-hours per gallon of sewage, the E.M.F. across the plates being 2·5 volts. The details of the electrical arrangements have been carried out with considerable skill by Mr. O. March.

THE PHYSICAL SOCIETY.

At the meeting of this Society, held on the 23rd inst., a note was read by Prof. J. V. JONES on

"The Use of Lessajou's Figures for Determining Speed of Rotation; and on the Direct Determination of the Vibration Period of a Reed or Tuning Fork by Means of a Morse Receiver."

In the measurement of electrical resistance in absolute measure by the British Association method, or by that of Lorenz, it is necessary to be able to determine with great accuracy the speed of rotation of the revolving coil or disc at the moment that the galvanometer readings are taken. It was in connection with a measurement of resistance in absolute measure by Lorenz's method that the author devised the method described in the present communication. The method consists in obtaining, by means of Lissajou's figures, an equality between the period of rotation and the oscillation period of a reed electrically maintained in vibration. In one end of the axle of the revolving apparatus is placed somewhat excentrically a pin which fits accurately into a hole in a rod having one end free, while the other end is constrained to move only in the direction of the length of the rod.

Fig. 1 shows the application of the method to determine the speed of rotation of a Lorenz disc. M M M is the axle about which the disc rotates. The dotted circle B represents the excentric pin, which fits into a hole in the rod S S, which is free at the end C, and is constrained to move only longitudinally at A.

To the free end of the rod a mirror, T, is attached. The vibrating end consists of a steel bar 100 centimetres in length, and of rectangular section (1·51 centimetres by ·60 centimetres), clamped in a massive iron frame in such a manner that the length of the vibrating segment can be varied at will. A rider is used for the final adjustment of the period of vibration. The reed with the electrical arrangement for maintaining it in vibration is shown in

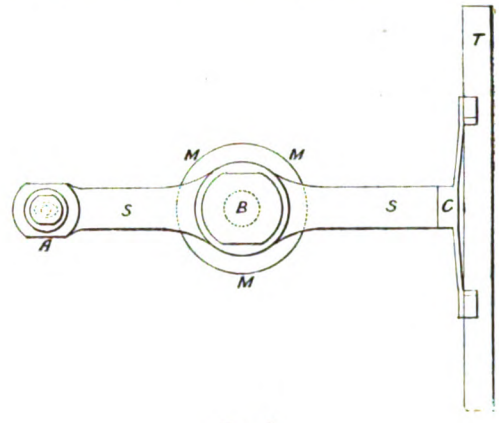

FIG. 1.

Fig. 2. A A A is the vibrating reed, C C the massive iron support to which it is clamped by the bolts and nuts D D. This support is itself clamped to a wooden block resting on a concrete floor. F F F is a wooden bar carrying the electromagnet M, and attached to the iron support at N N. On the side of the reed opposite to the electromagnet is a pair of springs S_1. One of these remains in contact with the bar, while the other makes and breaks contact with the first at each vibration. The two springs are connected through the electromagnet with the poles of a battery. A mirror, T, is attached to the free end of the reed. The apparatus is arranged so that the planes of motion of the rod attached to the revolving disc and of the vibrating reed are at right angles, and, therefore when synchronism is attained a spot of light reflected in both mirrors successively will be spread out into an ellipse, and the permanency of the ellipse will afford a test of the continuance of equality between the periods of rotation of the disc and the period of vibration of the reed.

In order to determine the vibration period of the reed a second pair of springs, S_2, exactly similar to the first pair, is placed opposite to them on the other side of the reed. These two springs are connected through a Morse receiver with a battery, so that a series of dashes will be recorded on the tape, the space occupied by a dash

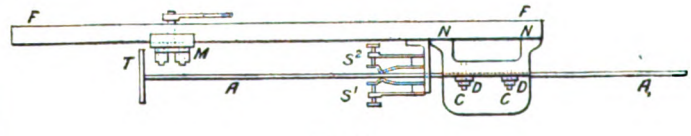

FIG. 2.

and the corresponding blank giving the period of vibration. To ascertain this, time signals are simultaneously recorded on the tape by means of a standard clock in the ordinary manner. By taking a sufficient interval of time the comparison may be made with any desired degree of accuracy.

The principal defect of the method is the impossibility as at present arranged of maintaining the rate of vibration of the reed constant, the variation exceeding one part in 1,000, while for the purpose required it should certainly not exceed one part in 10,000.

Prof. AYRTON observed that, in order to maintain the vibration period constant, the impulse should be given at the neutral point instead of at the extremity of each oscillation. Prof. Perry and himself had shown in a Paper communicated to the Society that it was possible to obtain a large number of notes of the harmonic scale from a single electrically maintained Koenig's tuning fork by simply altering the position on the fork, of the screw which made electrical contact.

Mr. BLAKESLEY stated that any disturbance, such as might be caused by persons moving about the room, or by the opening or

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shutting of a door, would disturb the uniformity of the vibration. He also stated that it was possible to maintain the period of vibration constant to within 1 part in 10,000 if the vibration were maintained by constant wind pressure instead of electrically.

Prof. S. P. THOMPSON said that when he saw the author's diagram on the black board he thought he was going to give them a method of giving the impulses at the neutral point. He thought this might be effected by means of a pair of springs making and breaking contact on opposite sides of the reed, and connected through an electromagnet with a battery. He stated that Langdon Davies, who is engaged in researches not yet published on harmonic telegraphy, has succeeded in constructing electric vibrators of constant period which give much better results than have been obtained with tuning forks. He thought that the author's apparatus would work better with a tuning fork in place of a reed, as it would not so readily communicate vibrations to the stand.

Prof. G. CAREY FOSTER suggested that a very simple method of determining when a vibrator, such as a reed or tuning fork, was in synchronism with a revolving disc, would be to attach a vibration microscope to the vibrator, and view through it a point on the revolving disc, which would, of course, have to be placed with its plane perpendicular to the axis of the microscope. When in synchronism a point at a suitable distance from the centre of the disc would appear to move with simple harmonic motion in a straight line.

Dr. HOFFERT then read a Paper by R. Threlfall and A. Pollock, of the University of Sydney, on

"The Clark Cell as a Source of Standard Currents, and on its Application to the Calibration of Sensitive Long Range Galvanometers."

The authors quite agreed that of the two possible methods of measuring small currents in absolute measure that adopted by Sir William Thomson in his ampere balances was preferable where the main consideration was the attainment of the greatest possible accuracy. In these instruments the action of the earth's magnetic force was entirely eliminated, and the only corrections which had to be applied were for the variation of gravitation at different places on the earth's surface. They were, however, subject to the inconvenience that it was necessary to maintain the force balanced in order to obtain a reading, and for many purposes a slight amount of accuracy might advantageously be sacrificed in order to obtain continuous and automatic readings. The authors have recently been endeavouring to construct for this purpose a galvanometer capable of giving very accurate measurements, and it occurred to them to examine the applicability of the Clark cell to obtain a standard current for calibrating the galvanometer from time to time, in order to correct for small secular changes in the magnetism of the controlling magnets or in the strength of the earth's magnetic field.

They found that a constant current could be obtained from the Clark cell provided the current taken from it did not exceed a certain value depending on the size of the cell. The Paper, which is a lengthy one, contains the results of a large number of experiments on Clark cells considerably larger than the ordinary type. These experiments have led the authors to the following conclusions :—

1. When a current is taken from a Clark cell, the terminal E.M.F. drops practically instantaneously to within an almost inappreciable amount of its final value.
2. At all events, to the first degree of approximation this value is constant, and shows that the electromotive force of Clark cells giving small currents is constant, and the same as when they are at rest.
3. There is no appreciable secular change.
4. The statement contained in 2 is true at all ordinary temperatures since the cell resistance is always small and there is no polarisation.
5. When the current is stopped the terminal E.M.F. rises instantaneously to within a few thousandths of a volt of the original value, showing again that the polarisation is practically *nil*.
6. The cell completely recovers in time.
7. The above statements are only true when the current does not exceed a certain value depending on the cell. For a cell in which the zinc and mercury surfaces have each an area of about five square inches or upwards a current of ·001 ampere will not be too great. For the ordinary small test-tube cell the current should not much exceed the hundredth of this.
8. When too large a current is taken from any cell the E.M.F. goes on dropping for some time, after which it rises slightly and seems to tend towards a fixed value.

The galvanometer described in this Paper, and shown in the accompanying illustration (Fig. 1), was intended for use in one of the hospitals of the Colony, and an accuracy within about 5 per cent. was all that was required, but the instrument was constructed to give results accurate within about one per cent.

The principal features of the instrument are—

1. The arrangements made for the support of the controlling magnet and for its adjustment without disturbing the suspension.
2. The damping of the needle by means of a thin copper cylinder suspended by a fine wire in clove oil.
3. Mechanical arrangements allowing of easy suspension of the mirror and adjustment of the damper.
4. The arrangement for testing with a Clark cell.
5. The curving of the scale in such a manner as to obtain direct tangent readings.

The instrument was provided with a single coil of rectangular section, having both its axial and radial dimensions 1·3 centimetre

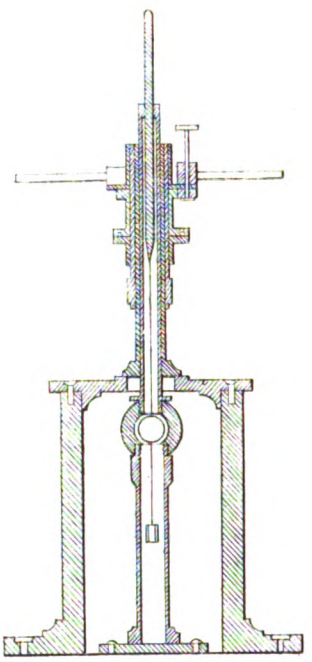

FIG. 1.

and 3·7 centimetre as radius of the inner layer. The coil consisted of 200 turns of copper wire ·0711 centimetres in diameter, and having a resistance of 2·02 ohms at 16° C, and was arranged to slide backwards and forwards with respect to the suspended portions while remaining parallel to itself.

Three positions of the coil were marked with respect to the suspended needles, and Mr. Adair, of Sydney University, calculated, by Maxwell's method of expansion in spherical harmonics, the law of deflection up to deflections of about 15° for each of these positions, and found that the deviation from the tangent law would never cause an error of more than 0·5 per cent.

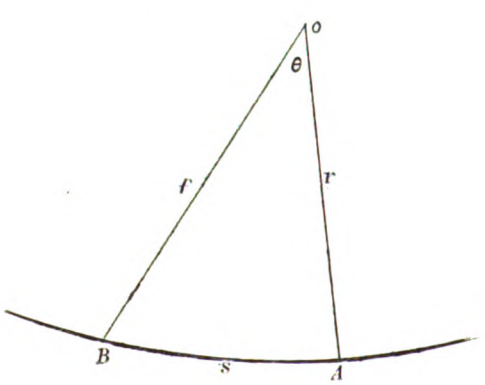

FIG. 2.

Mr. Adair also determined the form of the curve into which the scale of equal parts had to be bent in order to give direct readings, and a wooden block was cut to this form, and the scale attached to it.

This problem does not appear to have been worked out before, and the solution is of sufficient value to be placed on record.

Let A B (Fig. 2) be a portion of the curve required. Let O A = r be the apsidal distance, θ the polar angle subtended by the arc A B = s, O B = f, the distance of the spot of light from the mirror. A O is the line of incidence of the light.

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Assuming that the deflections obey the tangent law, the curve is given by the equation

$$S = 2\int \tan \frac{\theta}{2}$$

or,
$$\frac{ds}{d\theta} = \int \sec^2 \frac{\theta}{2}$$

whence
$$\left(\frac{df}{d\theta}\right)^2 + f^2 = \int^2 \sec^4 \frac{\theta}{2}.$$

This cannot be solved in general terms, but an approximate solution can be obtained if the range of θ is small.

Let $f = r + \lambda$, then developing in powers of θ, and retaining powers up to θ^4, the differential equation becomes

$$\frac{1}{r^2}\left(\frac{d\lambda}{d\theta}\right)^2 = 2\left(\frac{\theta}{2}\right)^2 + \frac{7}{3}\left(\frac{\theta}{2}\right)^4 - 2\frac{\lambda}{r},$$

writing λ^1 for $\frac{\lambda}{f}$ thus becomes

$$\frac{d\lambda^1}{d\theta} + \left(\frac{\sqrt{2}}{\theta} - \frac{7\sqrt{2}}{48}\theta\right)\lambda^1 = \frac{1}{\sqrt{2}}\left(\theta + \frac{7}{48}\theta^3\right)$$

whence

$$\lambda^1 = \theta^{-\sqrt{2}} e^{\frac{7\sqrt{2}}{96}\theta^2}\left\{c + \int \theta^{\sqrt{2}} e^{\left(1 - \frac{7\sqrt{2}}{96}\theta^2\right)} \frac{1}{\sqrt{2}}\left(\theta + \frac{7}{48}\theta^3\right) d\theta\right\}$$

Now $\lambda^1 = o$ when $\theta = o$, so that $c = o$, and to the order of θ retained

$$\lambda^1 = \frac{\sqrt{2} - 1}{2}\theta^2 + \frac{4 - \sqrt{2}}{96}\theta^4 = \cdot 207\,\theta^2 + \cdot 0269\,\theta^4.$$

The Clark cell used to standardise the instrument had a mercury surface of about 12 square inches, the zinc surface being slightly less. The cell was coupled up in series with a platinoid resistance of 1,417 legal ohms, which gave a current of ·001007 amperes, which was near enough for the purpose.

To set up the galvanometer the coil was pushed up towards the suspended magnet as far as it would go, and this was called the position O. The controlling magnets were then raised so as to give a mean sensitiveness, the known current put on, and the double deflection observed and indicated by a fiducial mark on the scale.

If any subsequent change in sensitiveness took place it would merely be necessary to bring the coil up to the O position, and then raise or lower the controlling magnets until, with the standard cell and the same resistance in circuit, the deflection reached the fiducial mark.

With the coil in a certain definite position, A, ·001 ampere corresponded to 10 scale divisions, and in a second marked position, B, the same current gave a deflection of one scale division. These positions were determined by the aid of a large storage cell, the E.M.F. of which was tested during the progress of the calibration. The galvanometer was tested in this way from ·001 ampere up to ·4 ampere, and found to give satisfactory results.

A METHOD OF EXAMINING RATE OF CHEMICAL CHANGE IN AQUEOUS SOLUTIONS.*

BY G. GORE, LL.D., F.R.S.

This research supplies an outline of a method of examining chemical change based upon the application of the "voltaic balance" to measuring the relative amounts of voltaic energy of electrolytes (*see* Roy. Soc. *Proc.*, Vol. XLIV., pp. 151, 294; *ibid*, Vol. XLV., p. 268), and the rate of chemical change is indicated by alterations in amount of such energy.

The author gives an example of two liquids, viz., a solution of equivalent proportions of potassic iodide and chlorine, and one of chloride of potassium and iodine, which, although having the same ultimate chemical composition, are greatly different, viz., as 31·76 to 1·0, in amount of voltaic energy.

The results of the experiments show that the solution of potassic iodide and chlorine was very unstable, highly sensitive to rise of temperature, had a great tendency to lose its voltaic energy, to change its chemical composition, and approach that of the other mixture. That the solution of the latter was very much more stable and much less sensitive to heat, but had a feeble tendency to absorb energy, to change its chemical composition, and approach that of the solution of potassic iodide and chlorine. The effect, therefore, of heating both liquids was to produce two portions possessing similar chemical composition and properties, consisting of about ·23 part of potassic iodide, 74·49 of potassic chloride, 126·8 of iodine, and ·0497 of chlorine. They also show that the solution of potassic iodide and chlorine decomposes spontaneously at 12° C. into potassic chloride and free iodine; that more than six days are necessary to effect the complete chemical change at that temperature; and that the rate of chemical change is much greater at the commencement of the action than towards its termination.

The collective results show that the "voltaic balance" method may be used to detect chemical changes of aqueous solutions, and to measure their rate. Its great advantage over the colorimetric method is that it is equally applicable to colourless liquids; it is much more sensitive and exact usually than either the colorimetric or the thermo-chemical method; and it is quick and easy of performance. It is being used to detect and measure chemical changes produced by light in aqueous solutions. The degree of freedom of an aqueous solution of chlorine from hydrochloric acid, and of iodine from hydriodic acid, was ascertained much more readily by this method than by ordinary chemical analysis.

* Abstract of a Paper read before the Royal Society, March 14, 1889.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, March 29th.

SOCIETY OF ARTS.

8 p.m. Indian Section. "The Progress of the Railways and Trade of India." By Sir JULAND DANVERS, K.C.S.I.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at the St. James's Hall Restaurant.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "Yeast." By A. GORDON SALAMON.

SATURDAY, March 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

MONDAY, April 1st.

ROYAL INSTITUTION.

5 p.m. Monthly General Meeting.

SOCIETY OF ENGINEERS.

7:30 p.m. Ordinary Meeting at the Westminster Town Hall. "Fire-proof Floors." By G. M. LAWFORD, A.M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture V., 2. "Instruments for the Measurement of Radiant Heat." By C. V. BOYS, F.R.S.

TUESDAY, April 2nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "The District Distribution of Steam in the United States." By Dr. Chas. E. EMERY, M.I.C.E. Time permitting, a Paper will be read on "Armour for Ships." By Sir NATHANIEL BARNABY, K.C.B. At this meeting the monthly ballot for members will take place.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. "The Argentine Republic." By F. K. SMYTHIES.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture. "Insects in Disguise." By Prof. RAPHAEL MELDOLA.

WEDNESDAY, April 3rd.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

7 p.m. Ordinary Meeting at the Westminster Palace Hotel. "The Roadstones of Somerset and Wilts." By JAMES BATEMAN.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Fruit Growing for Profit in the Open Air in England." By W. PAUL.

THURSDAY, April 4th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Houses and Their Decoration from the Classical to the Mediæval Period." By Prof. J. HENRY MIDDLETON, M.A.

FRIDAY, April 5th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Moulding and Casting Cylinders for Marine Engines." By R. J. DURLEY, B.Sc., Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "True and False Humour in Literature." By the Rev. Canon AINGER, M.A.

SATURDAY, April 6th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

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The Electrician.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 581
Note on the Bursting of Leyden Jars. By Dr. Oliver Lodge. Illustrated 586
Electric Lighting at the Erection of the Forth Bridge. By Alfred E. Mavor 586
Mr. Webster's Electrolytic Method of Sewage Purification. Illustrated 588
Physical Society—
The Use of Lessajou's Figures for Determining Speed of Rotation; and the Direct Determination of the Vibration Period of a Reed or Tuning Fork by Means of a Morse Receiver. Illustrated 589
The Clark Cell as a Source of Standard Currents, and its Application to the Calibration of Sensitive Long-Range Galvanometers. Illustrated 590
A Method of Examining Rate of Chemical Change in Aqueous Solution. By G. Gore, LL.D., F.R.S 591
Meetings of Scientific Societies. 591
The Anglo-Continental Cables 592
Reviews 593
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 595
Arc Lamps and their Mechanism. By Prof. Silvanus P. Thompson, D.Sc., M.I.E.E. Illustrated. Continued 596
Specific Inductive Capacity of Liquids 600
American Notes 600
Notes from Vienna 601
Correspondence—
The Fritsche Dynamo.—Jehl and Rupp 602
The Central Lighting Stations of France.—Ganz és Társa ... 602
The Richardson High-Speed Engine. Illustrated 602
Patent Record 603
Companies' Meetings, &c.—
The Direct Spanish Telegraph Company (Limited) 603
Submarine Telegraph Company (Limited) 604
The Telephone Company of Ireland (Limited) 607
New Companies Registered 607
City Notes, &c 607
Companies' Share List 608

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THE ANGLO-CONTINENTAL CABLES.

On Monday last the proprietors of the cables which have connected this country with France for a period of forty years, and with Belgium for thirty-six years, resolved to give up possession, and on Monday next these cables will be in the hands of the several Governments. The terms of purchase have not even yet been definitely agreed upon; but the directors of the Submarine Company obtained the authority of their shareholders to make the best bargain they can with the Treasury, and to place no obstacle in the way of the working transfer on the 1st of April. As to the price now offered for the cables we shall have something to say presently; but whatever comes of it, the event is of singular importance, not merely for the commercial interests now involved in the change of ownership, but because of the historic memories associated with a group of telegraph cables which will ever be regarded as the first parents of submarine telegraphy. Encouraged by certain experiments in crossing rivers and short stretches of water by means of insulated telegraph wire, Mr. Jacob Brett and others associated with him conceived the idea—a bold one at that time—of spanning the Straits of Dover, and thus connecting the two friendly nations on either side by an unbroken system of electric communication. In 1849 a concession for ten years—afterwards extended to forty—was obtained from the French Government, subject to a practical demonstration of the feasibility of the project within twelve months. This period of grace was by no means too long, for there existed really no data to go upon, and, both in respect to the character of the cable and

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the appliances for laying it, the promoters were almost in entire darkness. By a piece of good fortune they saved the concession; but they lost their cable, and had to begin the work over again. The facts are worth recalling. Dover and Cape Grisnez were respectively the points chosen for landing, and a copper wire, No. 14 gauge, covered with gutta-percha to the thickness of about half an inch, was to be the connecting link. This was the first submarine cable; and the machinery for paying it out was of an equally primitive type. Between the Admiralty Pier at Dover and the water's edge the gutta-percha was protected by a lead covering, but otherwise the cable was bare, and it had to be heavily weighted at intervals to induce it to sink to the bottom. In due course the boat which was paying out the cable arrived off Grisnez, where a lead covered cable had been provided on the shore, and to which the sea length was successfully attached. This was on the 24th August, 1850, and on that day—we believe from a bathing machine on the sands—intelligible signals were exchanged with the country from which the cable had been shipped. For the purposes of the concession, the experiment was a proved success; and it mattered little that a French fisherman next day accidentally hooked up the cable and cut it adrift with his pocket knife. He probably only anticipated by a few hours the catastrophe to which such a cable was certainly doomed.

By the following year a far stronger cable, approaching more nearly to the modern type, had been constructed, money being forthcoming to meet the additional cost now that the practicability of submarine telegraphy had been demonstrated. Four conductors of No. 16 copper wire, covered with gutta percha, served with tarred Russian hemp, and finally protected by ten thick galvanised iron wires, constituted the new cable, which was 24 miles long, and connected Dover with Calais. Though historically the second among submarine cables, the Dover-Calais cable was practically the first, and was certainly one of the best ever laid. The Grisnez line was perhaps never seriously regarded as permanent, and, at all events, was entirely abandoned. Only another year elapsed before a fresh cable was required to meet the traffic between England and France, and in the year following, 1853, a third cable was submerged, this time to connect us with Belgium. Anglo-Dutch and Anglo-German cables followed in due course, and in less than ten years from the commencement of its operations the Submarine Telegraph Company were working at least half-a-dozen excellent cables, ranging from 25 to 117 miles in length, connecting England with the Continent. That the business was highly profitable there is no doubt whatever, and, knowing what we do about cable laying, the risk was inconsiderable. But it appeared to be far greater in those days, and we cannot withhold our testimony to the courage and energy of the directors of this great company, who certainly paved and led the way for the greater enterprises which have resulted in submarine telegraphy throughout the whole world.

We have no exact knowledge as to the cost of the Anglo-Continental cables, the purchase of which is now under discussion, and any calculation is perhaps vitiated by the circumstance that the owners would naturally take into account the expense of repairs and maintenance, whereas the purchasers equally naturally consider this outlay as so much detracted from the intrinsic value of the articles. What the Government propose to do is to pay for the four French and the two Belgium cables about a quarter of what it would cost to lay entirely new cables of modern type. This, at least, is the estimate of the Chairman of the Company, and of course he is far from satisfied with the proposition, the expectation being that the shareholders would receive not less than twice as much. According to the only figures at our disposal, the aggregate length of the cables is about 370 statute miles, and reckoned at the price the Government propose to pay for them, namely, £22,330, their value per mile is set down at £60, or thereabouts. This is a ridiculously low figure, and we are not surprised that some of the shareholders described it as representing little short of spoliation. The cables, it is true, are the oldest in existence, but they appear to have suffered far less from age than from the accidental injuries inflicted by the anchors of fishing boats, which swarm in this very busy channel—injuries to which perfectly new cables would be as liable as the old. From the point of view of the Company, their submarine property is in good working condition; and when we are reminded that the cables have earned a net revenue in the last six months equal to the price now offered for them, it is impossible to deny the substantial accuracy of the description. Possibly one or two new cables may have to be laid in order to meet the higher requirements of the Government administration, but that would be a purely voluntary expenditure, for which the French and English nations will be amply recompensed, and affords no justification for appropriating the existing cables at little more than the price of old stores.

No doubt the chief difficulty in adjusting this bargain equitably now rests with the French Government, who, being hindered by the British Government from renewing the company's concession, have turned round and declined to be led in the matter of the purchase. The British Government, therefore, were responsible for the cancellation of the concession, and for the provisional agreement of July, 1878, which afforded the Company reasonable ground for supposing that their application ten years later would not be opposed. Certainly there was no reason to anticipate that their business would be compulsorily extinguished, and their property partially confiscated. This being the case it seems to us that the clear duty of the CHANCELLOR of the EXCHEQUER is to exert himself to the utmost in bringing the French Government to a more reasonable view as regards the value of these cables. The actual amount in dispute is a mere bagatelle, and divided between two of the richest nations in Europe is really not worth arguing about. From the company's standpoint, however, and also from that of all the companies possessing submarine cables connected with these shores, the principle involved in the transaction is a very important one; and we trust that it may not result in establishing a precedent which would be disastrous if applied to corporations which do not possess the peculiar advantages so long enjoyed by the SUBMARINE TELEGRAPH COMPANY.

REVIEWS.

Treatise on Submarine Telegraphy. By M. E. WÜNSCHENDORFF Director of Military Telegraphy, France. (Paris: Baudry and Co. 1888.)

(FIRST NOTICE.)

This very large and comprehensive treatise on submarine telegraphy of 565 quarto pages supplies a long and much-felt want. It exhibits from beginning to end an amount of careful research, skilful and systematic compilation, as well as a thorough knowledge of the subject. It is certainly most remarkable that it should have been left to a French officer to write the first and only complete treatise upon this important and interesting topic when we consider the fact that more than 90 per cent of all the submarine cables in the world have been projected, designed, made, laid, and are maintained by British capitalists, electricians, manufacturers, and telegraph companies. British submarine cable manufacturers and electricians have naturally been very conservative in regard to their special knowledge and experiences. They were the practical and successful pioneers of submarine telegraphy, and having spent a

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great deal of thought, time, and money in acquiring their knowledge, they could scarcely be expected to publish all they knew about it. No doubt a large amount of the information found in M. Wünschendorff's book has been compiled from English publications (he acknowledges some of these sources), yet there is a very great deal that has never before appeared in any English journal or book, more especially in regard to the manufacture and laying of cables, which will be read with interest even by those most intimately acquainted with these operations. M. Wünschendorff has had exceptional opportunities of becoming intimately acquainted with all the various details connected with submarine telegraphy, for he has taken a leading part in the laying and repairing of most of the French Government cables. He was sent over to the India Rubber and Gutta Percha Company's Works, Silvertown, to test and inspect on behalf of his Government certain cables made by that firm, and he was also on board the Eastern Telegraph Company's cable ships s.s. "John Pender" and s.s. "Chiltern" when they were engaged in laying and repairing French Government cables in the Mediterranean.

We shall first give a general idea of the scope of this treatise, and then refer more particularly to some of the details. It is divided into five parts :—

I. The History of Submarine Telegraphy from the original idea, and experiments by Sœmmering carried out at St. Petersburg in 1807 until the immersion of the 1886-87 Atlantic cables.

II. The Composition and Manufacture of Submarine Cables.

III. The Laying and Repairing of Submarine Cables.

IV. The Testing of Cables during Manufacture and Laying, as well as for localising the position of faults.

V. The Apparatus and Systems Employed in Telegraphing by Long Submarine Cables.

Part. II. is divided into five chapters—(1) Conductors ; (2) Insulating Coverings ; (3) Outer Sheathings and Servings ; (4) Different Kinds of Cables, and their resistance to breaking ; (5) Jointing and Splicing Cables, with extract table of specifications of different cables from Rankine's Rules and Tables (Sixth Edition).

Part III. is divided into five chapters—(6) The Machinery and General Arrangements of Cable Ships ; (7) Grappling and Buoy Ropes, Chains, Mushrooms, Grapnels and Buoys ; (8) Sounding and Surveying Apparatus and Preliminary Surveys ; (9) Laying of Submarine Cables ; (10) Repairing of Submarine Cables.

Part IV. is divided into four chapters—(11) Testing Instruments, such as Galvanometers, Electrometers, Wheatstone Bridge, &c., and Batteries ; (12) Testing of Batteries and Galvanometers ; (13) Measuring the Conductor Resistance, Insulation Resistance, and Capacity of Cables, Testing Joints, Tests during Submersion of Cables, Examples of Test Forms ; (14) Localising Faults by Different Methods.

Part V. is divided into two chapters (15) Theory of the Transmission of Signals, Employment of Condensers, and Speed of Signalling ; (16) Sending and Receiving Apparatus, such as Relays, &c., Sir William Thomson's Mirror and Siphon Recorder, Duplex and Quadruplex Telegraphy.

The historical part is very interesting, and tells a tale that has been often told before. It is, however, put in an agreeable and readable style ; it brings forcibly before the reader the difficulties which beset and were surmounted by the pioneers of submarine telegraphy, and on the whole awards just credit to those who most prominently took a lead in the same. The early designs of Wheatstone for making and laying cables, as published by Sabine in 1877 in the *Journal* of the Society of Telegraph-Engineers, have been neatly reproduced and explained. The work done by Brett, Read, Willoughby Smith, F. C. Webb, and others is duly taken notice of. Very clear and well done illustrations of some of Newall and Co.'s early cables, of the 1857 and 1866 Atlantic cables, of the paying out gears of the "Agamemnon" and the "Dix-Décembre" (still at work on the Channel cables and now called the Ampère), together with charts of the routes taken by the North Atlantic cables near their landing places in Europe and America, and a large general map of the present chief cable routes, prepared from official documents supplied by the International Bureau of Telegraph Administration, are to be found in this part of the book. The commercial and administrative aspects of this interesting period in the history of submarine telegraphy have naturally been omitted in a book dealing almost exclusively with electrical and mechanical details : consequently, the names of those who most prominently sustained and maintained these undertakings by their courage and pecuniary support have not been mentioned.

In Part II. an exhaustive analysis of the mechanical and electrical qualities of copper, and the reasons assigned for its use as the conductor of submarine cables, is given, together with illustrations of the apparatus used for stranding the conductor wires.

The cultivation of gutta-percha and India-rubber trees, the physical and chemical properties, the purifying and methods of covering the conductor with these dielectrics, are very fully explained and illustrated. The improved gutta-percha by Willoughby Smith, with tables of tests after one minute's electrification, is also noted. Other insulating substances, such as Hooper's core, Wray's composition, ozokerite, nigrite, kérite, Bruce Warren's India-rubber, the cables of Berthoud-Borel and Brooks, are here referred to. We would, however, have expected to find more information and illustrations of these newer kinds of insulating material than has been given by M. Wünschendorff.

Chapter 3 deals with the preparation, the mechanical resistance and machines for covering cores with hemp. It then treats of the iron sheathing and the various machines employed by manufacturers in covering the core with the iron armour and outer coverings, of Clark and Bright's bituminous composition, as well as Messrs. Johnson and Phillips' tape. We are astonished, however, to find no mention of the method of applying Clifford's brass or Muntz's metal tape, which is so largely used by the Telegraph Construction and Maintenance Company to cover the gutta-percha cores of the Eastern Telegraph Company's cables, so as to prevent them being pierced and damaged by teredoes and other marine borers (*see* "Munroe and Jamieson," Sixth Edition, page 279).

Chapter 4 deals with multiple conductor cables, and illustrates the cable made by M. Menier for the mouth of the Seine, as well as the machine for serving the multiple cores with jute yarn. Next we have an illustration of an old-fashioned tripod apparatus for testing the breaking stress of cables, with a few remarks on the depth to which cables of different strengths may be prudently submerged without breaking during laying. The light cables proposed by Baudoin and Allan, Siemens, Duncan, Rowett ; floating cables, Blondot and Bourdin, and finally those of Captain Trott and Mr. Hamilton (the latter being beautifully illustrated), are severally mentioned and their peculiarities reviewed. M. Wünschendorff concludes this chapter by alluding to the great inequalities frequently met with by cable engineers in different parts of the world, especially noticing a case of sudden inequalities in the Levant, found by the reviewer, and draws the conclusion that light cables would fare very badly under such circumstances. We fancy that Messrs. Trott and Hamilton would take another view of the case, and affirm that their light cables would so beautifully fit the sinuosities of the bottom of the ocean that they would seldom, if ever, require repair. Chapter 5 is very complete in regard to the scarfing and soldering of the conductor, the making of gutta-percha joints, as well as the splicing of the sheathing and lapping with outer serving, but incomplete and not illustrated in regard to India-rubber or Hooper's core. We fancy that M. Wünschendorff has had no practical experience with these kinds of core, and in a second edition he should make good this omission.

Chapter 6 begins with a reference to cable ships. The s.s. "Faraday" is instanced as a model ship for laying long cables, while the s.s. "Pouyer-Quertier" is considered as the type of repairing ship. No plans of any modern cable ship are given, and we consider this an omission which M. Wünschendorff should remedy in the next edition. The separate details of the cable machinery, however, receive considerable attention and illustration, such as cable tanks and their fittings, coiling of cables in tanks, changing of tanks during paying out, and the formulæ for ascertaining the length of cable that can be coiled in a tank. A curious omission is made here in not taking into account

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the percentage loss of length due to wooden feather edge. Mere reliance on the formulæ will not give accurate results, as it supposes perfect coiling without the necessary intervening slips of wood. Excellent illustrations are given of a paying-out drum, with double Appold brakes and dash pots, as well as picking-up gear, but no mention is made of the makers or the ship to which these were applied. We may here point out a general fault throughout the whole book, viz., that no descriptive names of the different illustrations are given under any of the figures, simply the number, which necessitates turning over the text to find out their meaning and object. This defect should also be rectified in a second edition. The only illustration given of a dynamometer is the old one of the Great Eastern. These useful instruments have been considerably improved upon. M. Lacoine's mathematical investigation (which appeared in *Engineering* in 1885) of how to calculate the dynamometer readings is reproduced in full, but no reasons are given for the statement "that the cable stresses are not accurately indicated by the dynamometer when the cable or grapnel rope is in motion." The bow-baulks gear of the s.s. "Faraday" is illustrated and described, but the method employed by the Eastern Telegraph Company of building in the bow-gear along with, or making it a part of, the ship, and thus constructing a comfortable, easy platform to work upon, as well as of rendering the whole thoroughly firm and secure, is preferable for small repairing vessels to the one-sheave swivel arrangement on board the "Faraday."

Chapter 7, as we have already mentioned, deals with grapnel and buoy ropes, shackles, chains, mushroom anchors and grapnels. The *old* form of Jamieson's self-relieving grapnel is given at p. 216. Lambert's grapnel for hooking a cable at great depths, and then cutting and relieving one side, but holding on to the other, is fully described, but we find no mention of the more successful Messrs. Johnson and Phillips' patent grapnel, which aims at effecting the same purpose. Kingsford's tell-tale grapnel, with central insulated conductor from the fillets of the grapnel toes to the ship, with battery cell on board for automatically announcing to those in charge when the cable has been hooked, is neatly illustrated and described, but it is condemned for great depths. Now, this modification of the ordinary grapnel is more especially useful at great depths, first, on account of the great difficulty of knowing when the cable has been hooked with a long drag-rope and heavy normal stress on the dynamometer; and, secondly, from the long time occupied in making sure that it has been fairly hooked by having to heave up the slack before the peculiar springy feeling of "cable hooked" is experienced. We understand that Captain Trott has successfully used this grapnel in depths of 2,000 fathoms and upwards in repairing Atlantic cables.

M. Wünschendorff is mistaken in stating that grapnel ropes exclusively of Manilla have been used for great depths to minimise the normal stress, the practice being to have, say, two or three hundred fathoms of ordinary grapnel rope next the grapnel chain, then Manilla, and sometimes a length of ordinary grapnel rope next the ship, so that the wear and tear which must naturally take place at each end is withstood by the ordinary compound rope, whilst the long intermediate length of Manilla rope greatly lessens the normal working stress. One of the best-illustrated and described portions of the book is that which deals with buoys, but a table of the depths for which each kind and size of buoy is most suitable, as well as the composition, sizes and weights of buoy and grapnel ropes, would have still further improved it. A most vivid full-page picture is given of the "Great Eastern" lying off a big Atlantic buoy prior to picking it up, the ship's dingy boat being kept close up to the latter until the agile cable-hand, who is struggling manfully in his perilous position, unships the buoy moorings. In the next illustration the buoy is represented as being heaved on board the great ship.

Chapter 8 is devoted to sounding and sounding machines, Sir William Thomson's well-known deep-sea sounding machine receiving full attention, as well as the many devices for slipping the sounding weight when it reaches the bottom in deep water, Mr. Chas. H. Phillips's method being attributed to a M. Benest (*see* Figs. 215, 216). Flying soundings are merely referred to, and we think that M. Wünschendorff might have introduced a figure of Sir William Thomson's latest form for this purpose, which is now a recognised necessity on board not only every cable and surveying ship, but also every passenger ship of importance. This chapter concludes with a *résumé* of some of the more important marine surveys. Too much stress cannot be laid upon the importance of thoroughly surveying and selecting the most suitable route and bottom for a cable *prior* to its immersion. *a. γ.*

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

Section III.—Magnetic Fields of Coils and Solenoids.

(*Continued from page 540.*)

148. *Direction of Field Due to a Solenoid.*—A solenoid, mounted as in Fig. 143, is very suitable for observing the direction of field set up. One layer of stout wire, say, No. 12, is first wound round a cylindrical surface such as a battery jar, to give it the proper shape which it will be found soft enough to retain itself after slipping off. It is better to leave a little clear space between each turn, so that afterwards when experimenting you can look down into the middle of the coil. If this is done there is no need to have the wire insulated. Let the two ends be passed through the wooden base block B carrying the two terminals, and solder the wires underneath this block to the extremities of the terminals. Clamp the coil down by a flat piece of wood screwed down to the base block, as shown This keeps the solenoid firmly in position, and affords a little table whereon to put your compass needle when examining

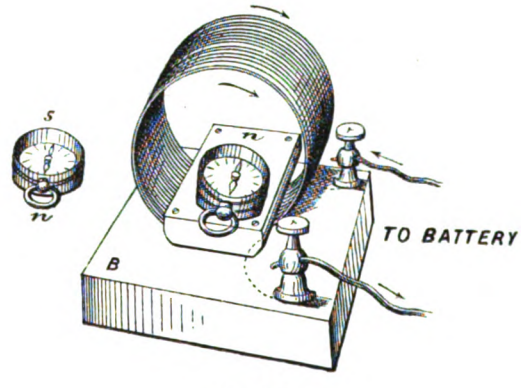

Fig. 143.

the field in the interior. A convenient size of solenoid is about from four to six inches in diameter, and, say, one foot long. Before passing the current through let the solenoid be placed so that the direction of its length is at right angles to the magnetic meridian, and then put a compass needle inside, or, better still, place the compass inside first and then turn the whole apparatus bodily round till the needle points at right angles to the direction of length of the solenoid. If another compass needle be placed *outside* the solenoid in the position shown in the Figure, both needles will point the same way, north and south, before the current is passed into the coil; but immediately the current is switched on the needles will turn sharply in opposite directions, and when at rest will lie very nearly in the direction of length of the solenoid. Notice should be taken of the direction of the current and the direction of movement of the needles. In the Figure the needles are shown as they are deflected when the current passes through the solenoid in the direction of the arrows. We now see the direction of the field by the direction towards which the north poles of the needles point, and we find by exploring all round the solenoid that the lines seem to flow along the interior space of the coil and then to separate into two streams passing *backwards* along the exterior sides of the

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coil, and then turning in again to the centre. This can be best observed by cutting out a piece of card as in Fig. 144 bending it upwards at the dotted line, and slipping it over the coil in the manner shown in Fig. 145, the centre portion, A, being then bent downwards again so as to lie along the interior of the coil. By passing the current through the coil again, and letting fine iron filings fall on the card, the character of the entire field is delineated. Supposing the current in

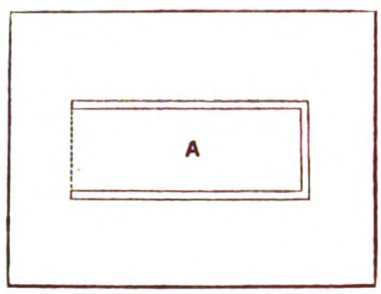

Fig. 144.

the coil to be in the same direction as in Fig. 143, we shall find that wherever we place small compass needles the direction in which their north poles turn will be along the arrows marked on the card, and the direction of field in any plane surface cutting the coil is exactly similar to that found on the plane of

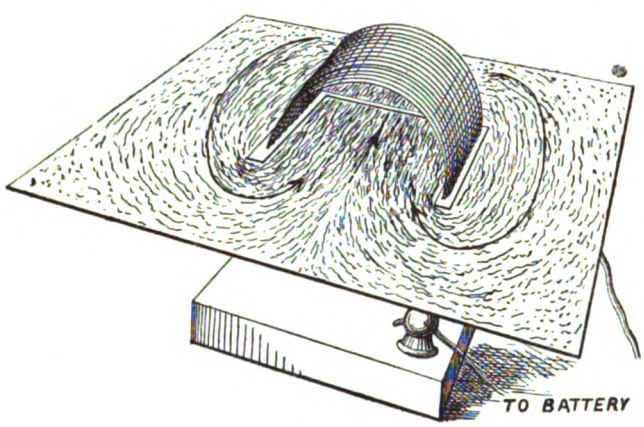

Fig 145.

the card; hence, when we think of the field of a coil or solenoid we must carry in our minds the conception that the field entirely envelopes the coil. In other words, the lines of force fully occupy the interior space of the coil, and after passing

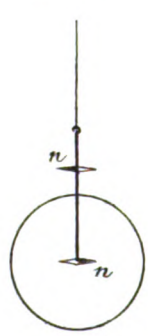

Fig. 146.

through this space divide evenly and flow *backwards* round the outside; and with this conception it will be easily understood that if we attach two magnetic needles rigidly together, as in Fig. 146, with their north poles pointing opposite ways, and freely suspend them by a silk thread, so that one is inside the coil and the other outside, as shown, both needles will turn in the same direction when a current is sent through the coil. The two needles together, or, as the combination is technically called, the "system of needles," is hardly at all affected by the earth's horizontal force, because what force it exerts on one needle is counteracted very nearly by the force on the other; in fact, if the two needles were of exactly the same magnetic moment, the "system," when allowed to swing freely in the earth's field, would not come to rest in any definite position, and hence the "system" is called an "astatic" system. It will be seen that as the earth's field has very little controlling effect on it (only just enough to keep it at zero) the astatic system is very sensitive. It is usual to have two separate coils, one above the other, and each containing and acting upon one of the needles, but when the idea was first developed one coil only was used. Faraday mentions in his renowned "Experimental Researches" the use he made of an astatic system with one coil (Fig. 146) in carrying out some induction experiments. And the writer has introduced it here believing it to be of interest in connection with the direction of field in and around one coil *alone*; and, indeed, in an earlier part of this series (para. 57) reference was made to the same subject, the explanation of which now will make the case there given better understood.

Lastly, if a compass needle placed inside the coil be moved outwards along the axis either way, it will be found that its deflection keeps pretty nearly in line with the axis until it emerges from the coil, when the deflection rapidly falls off; and ultimately, by removing the needle further and further away, we find the field of the coil exerts practically no more force on it, and it rests in the meridian once more. It is precisely this variation of field along the axis that we wish to determine for any kind of solenoid; and further than this, to determine in C.-G.-S. units the exact intensity of field at any point.

(To be continued.)

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(Continued from page 572.)

In the Thomson-Houston lamps so widely used in the United States, a peculiar clutch is employed, consisting of a pair of levers jointed together, one of them being perforated with an eyelet through which the carbon rod passes. The mechanism of this lamp, shown in Fig. 14, consists of a see-saw lever, L L, pivotted at O, and provided with a long tail, T, the motion of which is moderated by an air dash-pot. Below is an electro-magnet, M, in the main circuit, and above is a second, S, which is connected as a shunt. The pole-pieces of both are of conoidal shape, protruding through apertures in the armatures, *a a*, and *b b*, to give longer range of pull. The lower and upper arms of the clutch, marked R and *k*, close together when the tail, T, rises, gripping the carbon rod, C, and raising it. From this diagram, which also shows the electric connections, it appears that the current entering the lamp through an insulated terminal at +P, flows first round M, and then goes to the frame of the lamp. Thence it divides, the main current finding its way to the upper carbon holder, and so through the arc to the lower carbon, whence it returns (by a route not shown) to the insulated negative terminal, −P. A smaller portion of the current flows up round the shunt electro-magnet to −P. The arc is struck by the preponderating main-circuit current in M attracting the lever end of the see-saw lever, and raising the clutch. The feeding is accomplished by the preponderating pull of the shunt magnet as the arc increases in length. The resistance wire across from +P to *c* constitutes a cut-out circuit, which is brought into operation by the augmented current in S on any failure of the main current. The small coil connected across from +P to the lamp frame is a mere adjustment to regulate once for all the power of the series coil, *m*, relatively to that of the shunt coil, S.

It will be noted that in the operation of all these clutch actions there are really four periods. In striking the arc there is a first stage of affairs, where the clutch rises sufficiently to grip the carbon rod, immediately followed by a second stage, during which it rises still further, and lifts the carbon rod, so striking the arc. During the third stage or period the clutch still retains its grip, but as the arc burns away the clutch is gradually lowered. This is due, in constant potential lamps, to the weakening of the main current; in constant-current lamps, to the increasing opposing action of the shunt. The fourth stage is reached when the arc has burned away so far that the clutch has been lowered to the point where it begins

* Paper read before the Society of Arts on March 6, 1889.

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to relax its grip, and now feeding commences, the rod slipping a little, but the clutch simultaneously rises a little, and grips again, again to descend. In a well-adjusted clutch lamp the clutch is indeed incessantly rising and falling through minute distances about the critical position. A bad clutch, or one that is deranged by dirt, will overfeed, and then rise too far, feeding spasmodically. Theoretically, all these clutches possess the retractile property so useful in keeping a steady arc when the carbons are of indifferent quality. But it is obvious that their perfection of action is impaired by dirt, dust, and inequalities in the surface of the carbon rod due to wear and tear.

Clutches of the class termed "forward-feeding" belong to a different category, as they have, for the most part, no retractile power. In Newton's form (1623[83]) a piece of steel curry-comb, bent so as to form a sort of lobster-trap, encircles the carbon rod, and forces it gradually forward when mechanical vibrations are imparted to it by a lever, working with a vibration on the plan of the well-known electric-bell vibrator, from the armature of a shunt-magnet. The latest variety of this species of forward feed is that of Holmes (769[86]), shown in Fig. 15. Here, a shunt electro-magnet, S, attracts to the periphery of a wheel first grips the wheel, then turns it a little. In weaving machinery the "feed" acts in the direction in which the clutch propels the wheel, but in its application to the arc lamp the action is reversed, for the weight of the carbon rod propels the wheel in a direction opposed to the grip of the clutch, and the feeding takes place at those instants when the clutch releases its grip. The matter is best studied by reference to actual cases. Fig. 16 depicts the clutch-wheel of Common and Joel. The descending rack R drives the wheel D by means of the pinion P. Pivoted loosely around the same arbor is a heavy lever, which is prevented by a stop, S, from descending too far. Pivoted to this lever at L is a second lever, with an enlarged end to grip against the surface of the wheel. The tail of this nipping lever is attached by a pin to the iron core of the solenoid, M. (The latter is wound with a main-circuit coil only if wanted for use in parallel, or with a main coil and an opposing shunt coil if for use in series.) When the current in the solenoid draws up the core, the nipping lever first turns around L and grips the wheel; any further rise of the core will cause the two levers and the wheel to turn bodily together round the arbor, and this second action causes the arc to be struck.

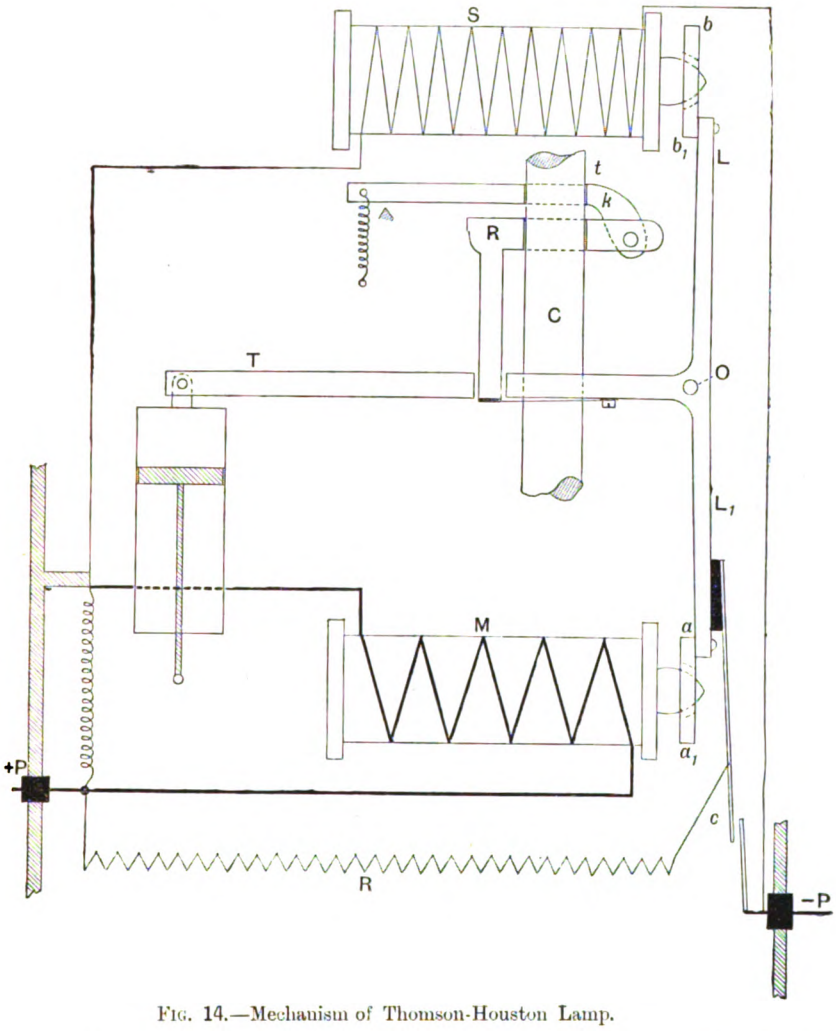

Fig. 14.—Mechanism of Thomson-Houston Lamp.

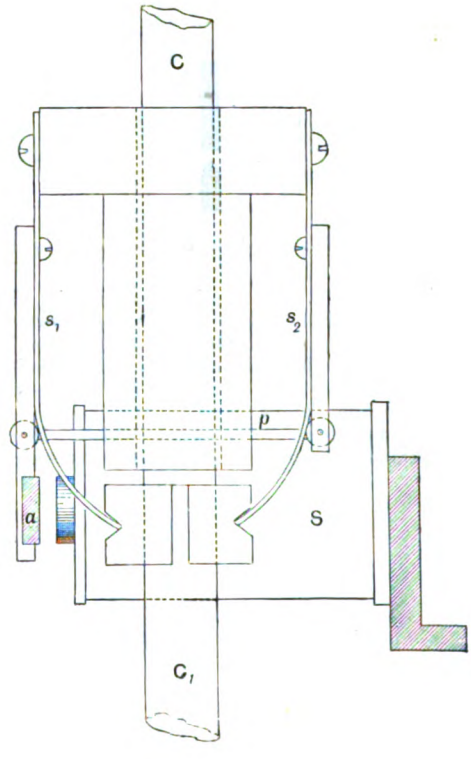

Fig. 15.—Holmes's Feed.

an armature, a; the latter being mounted upon a vertical lever. The carbon rod $C C_1$ is gripped between two blocks, which are pressed against its sides by two curved springs, s_1 and s_2. The armature lever is attached to s_1, and is connected across by a small rod, p, to the spring s_2. When the armature a is alternately vibrated backward and forward by the magnet, the gripping blocks propel the carbon downwards. The make-and-break device which turns the current off and on in the magnet coils is not shown in the cut. It consists of an ingenious modification of Holmes's snap-switch.

Passing to the *clutch wheel* or *brake wheel* type of lamps, we may remark that although so far back as 1861 Gramme attempted to construct on this plan a lamp (the existence of which was only published to the world in 1888 by M. Fontaine), this species of mechanism appears to be essentially British. The device of applying a clutch to a wheel in order to feed that wheel forward by degrees, the reciprocating motion of the clutch lever being converted into a motion of rotation of the wheel, is already familiar to engineers in the so-called "silent feed" movements used in spinning and weaving machinery. A clutch applied

Then begins the third period of action, during which the levers slowly descend until the weight-lever touches S. Then the fourth period begins; any further descent of the core causing the nipping lever to release its grip, and allowing feeding to take place, followed by a slight rise in the core and renewal of grip.

A form of clutch-wheel lamp which has become deservedly popular of late is that known as the Brockie-Pell (4419[82] and 12681[85]). The see-saw belonging to this lamp was shown in Fig. 6. The descending carbon rod drives a wheel having a strong projecting rim, at the inner surface of which a brake is applied. This consists of a small leather pad, m, fastened to a short arm which projects downwards from the nipping lever, L, pivoted at Q to a sector-shaped lever behind, which carries two weights, W W, to increase its downward-bearing power. This weight-lever is loosely pivoted on the arbor, P, and turns solidly with the wheel when the brake is applied. There is a stop, S, to limit the descent, but it is in this case applied to the tail of the nipping lever. A connecting link, E, joins the nipping lever, L, to the see-saw. The internal position of the brake appears to have two advantages, namely, longer leverage around the fixed pin, making the feed more sensitive, and

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greater protection from dust and dirt. One peculiarity of the Brockie-Pell lamp is seen by reference to Fig. 6, namely, the device by which the core, B, of the shunt coil is allowed a certain travel upwards before it pulls at the see-saw lever, its thinner part passing freely through a swivelled washer, *w*, on the see-saw. But the washer is of iron, and the core has an enlarged head, *h*. These adhere by magnetic attraction when the shunt coil comes into operation.

Another very successful form of lamp is the Crompton-Crabb "double differential" (2539[83]), shown as a whole in Fig. 18, and in

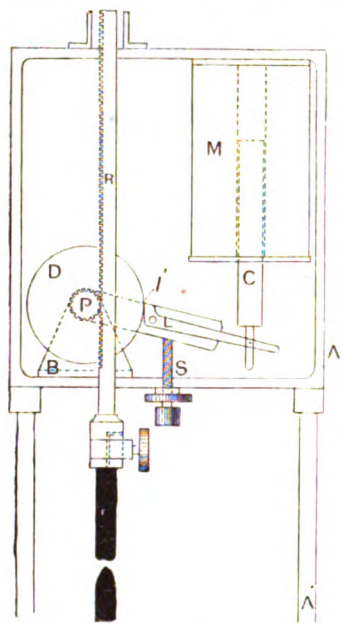

Fig. 16.—Common and Joel's Clutch-wheel.

detail in Fig. 19. In the lamp shown in Fig. 18 there are two carbon rods, M and N, of which N comes first into operation, afterwards changing over. On each carbon rod is cut a rack which drives a brake-wheel, or, rather, a pair of brake-wheels, one behind the other on the same pinion. The arbor bearing is not, as in the two preceding lamps, fixed in the frame of the lamp, but passes through a short sleeve or jockey, which, when the wheel is free to turn, can slide up or down on the carbon rod, but is prevented

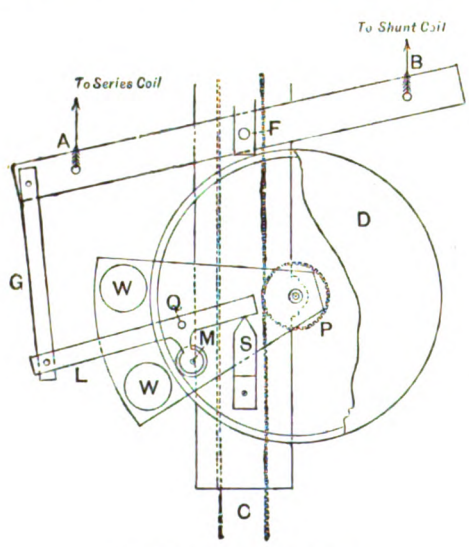

Fig. 17.—Brockie Pell Lamp.

from turning sideways by a guide-pin, *g*, above. Below the brake-wheels stands a lever, L, pivoted at *o*, and attached by a link, H, to the core of the solenoid overhead. This lever carries a small table, *t*, and a brake-piece, *b*, faced with phosphor-bronze. When the lamp is out of action, the free end of the lever is down, and the weight of the wheels and the carbon holder bears down upon the table *t* through a pin, *p*, which projects down from the jockey-sleeve. In this position the wheels do not touch the brake-piece, *b*, and are free. When the current is turned on, the main coil of the solenoid attracts its core, first drawing up the lever, which, turning on its pivot as it rises, brings the brake-piece against

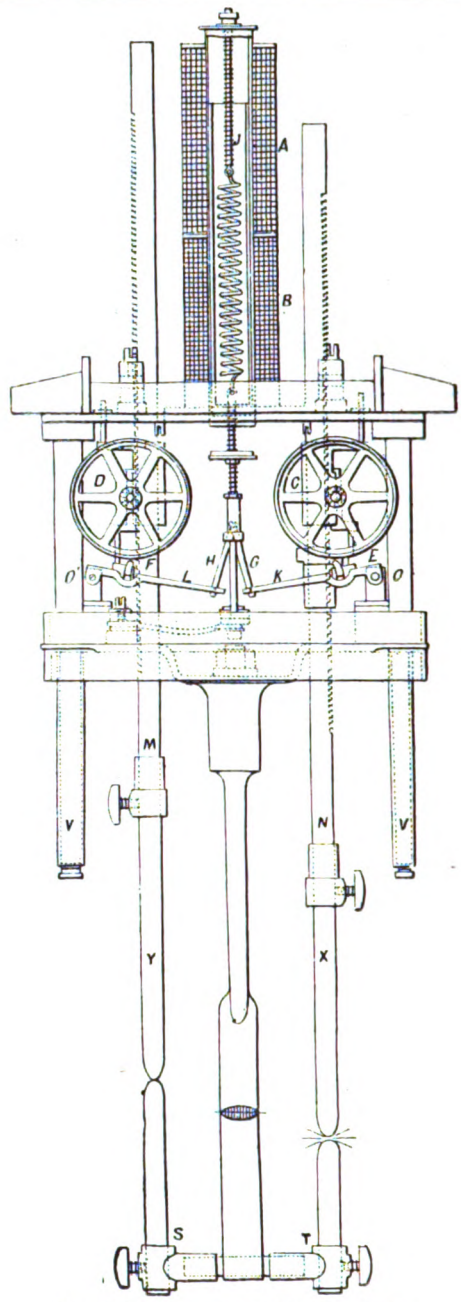

Fig. 18.—Crompton-Crabb D D Lamp.

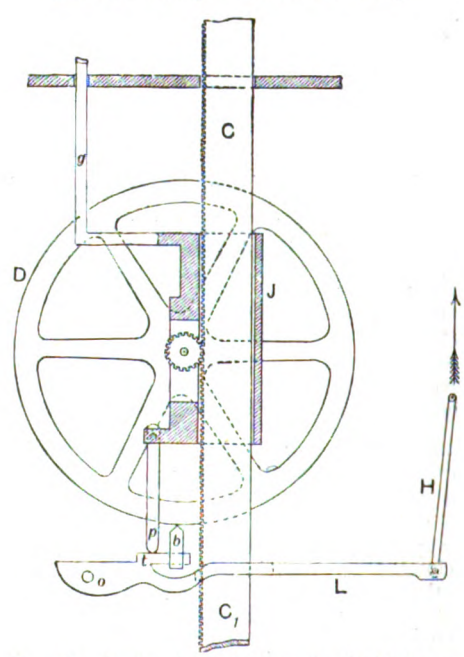

Fig. 19.—Brake-wheel of Crompton-Crabb Lamp.

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the rim of the brake-wheels and clamps it. Secondly, the wheels being thus prevented from turning, any further rise of the lever lifts the brake-wheel, jockey, and carbon-holder bodily (the weight of them all resting on the break-piece), thus striking the arc. Thirdly, as the arc burns away the lever again descends, until, fourthly, when the tail-piece rests on the table and takes the weight off the break, the feeding begins. There are many other points of interest about this lamp which cannot here be discussed.

Other forms of brake-wheel have been used with success, notably an elastic band-brake, resembling Appold's well-known device, applied outside a smooth wheel, in Statter's lamp (2985[85]).

The most recent form of clutch-wheel is that devised by Alexander Siemens, 6987[87], illustrated in Fig. 20. The lamp to which this device is applied is a holophote lamp for search-lights, with a screw feed, the screw being turned by this clutch wheel. It is about one inch in external diameter, and has a projecting rim, R, within which lies an internal metal ring, B, slightly sprung outwards, and cut obliquely, somewhat in the manner of the elastic metal packing-rings used in engine pistons. The two ends of this internal split ring are joined by two pins to a small lever, L, which projects outwards. When a reciprocating motion, of either large or small range, is imparted to the forked end of this lever, this internal clutch alternately bites against the rim and pushes it forward, and then releases its grip and draws back. This device, which appears to be a really new mechanism, constitutes a true positive feed.

The same device reappears in a recent lamp by Fein (1888) which has a main circuit-magnet striking the arc by drawing down the lower carbon, and a shunt-magnet for feeding, which vibrates an armature by make-and-break arrangement. The upper carbon holder is smooth, of rectangular section, with a smooth feeding roller firmly pressed by a spring against it. This feeding roller is attached to a clutch wheel like Fig. 20. The lamp will work even upside down. Unlike the clutch-wheel devices previously described, Fein's feed is non-retractile. The latest patterns of clutch-wheel feeds are those of Mackie (7184[87]) and Mathis (10740[87].)

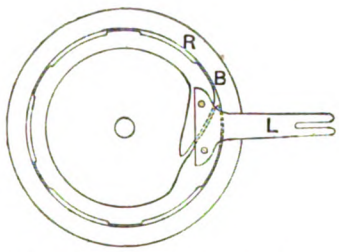

Fig. 20.—Siemen's Clutch-wheel.

The advantages of the clutch-wheel mechanisms over the clutches that act directly on the rods may be summed up by the remark that they render the operation of the lamp independent of dust and dirt.

Of lamps with *screw-feed* motions the most recent are the projector lamp of Siemens (6987[87]) mentioned above, and a motor lamp by Maquaire, which is now being used at the Kensington-court lighting station. In the latter an ingenious and simple method of reversing the motion of the motor armature is adopted, so that both striking and feeding are accomplished by the same screw. This lamp is further described below.

The class of lamps in which cord and pulley mechanism is employed in conjunction with a long-range open solenoid goes back to the early examples of Archerau and Jaspar. In the more complex Pilsen lamp (Krizik and Piette, 1397[80]) two solenoids are used, each with its own coned core, the plungers being connected by cord and pulley, and each bearing one carbon pencil. The arrangement of the circuits of the recent form of lamp is shown in Fig. 21, the core A being drawn into the main-circuit solenoid C to strike the arc, whilst the differentially-wound solenoid P varies its pull on the core B according as the carbons are required to approach, to stand still, or to recede, the former action occurring when the shunt current prevails. The special cut-out mechanism E F will be alluded to later.

A much simpler pattern of lamp has been several times described with various modifications in detail by Jasper, 1878; Romanze (3901[84]), Andrews (3393[82]), and lastly by Menges, 1887, whose form is shown in Fig. 22. Here the long core S N is drawn up into the solenoid, wound differentially with a coarse wire, A, and a fine wire winding, B. A heavy piston of metal on the top of the upper carbon holder *d* serves both to counterpoise the weight of the core and to check, as it slides in the surrounding tubes, any too sudden movements. It is often claimed for solenoid lamps that the absence from them of all mechanism renders them superior to all other species of lamps. Yet they are not free from defects; they do not always burn steadily; some of them have the evil habit of "pumping;" and so simple a matter as the elongation of the cord which connects the plungers may put their regulating properties to confusion. In a recent modification by Doubrava the iron cores are fixed, and the solenoid coils slide up and down over them, giving motion to the carbons.

The *screw-feed* lamps have been already touched on. Of these the most successful in practice is the Cance lamp (3976[81]), which operates by the weight of the upper carbon. The screw is prevented from turning by a nut gripped until feeding is necessary. In Siemens' holophote lamp (6987[87]), and in Maquaire's new lamp, 1889, the mechanical turning of the screw forces the carbons forward.

Amongst *magnetic-clutch* lamps the Gülcher lamp, as improved by the Gülcher Company (Whiteman, 1915[82]), still holds its own. In this lamp the single counterpoised horseshoe electro-magnet—with unequal limbs—sticks itself on by one pole to the iron carbon rod, and by the other pole attracts itself upward to strike the arc. For constant potential work it is a very steady lamp. More recently,

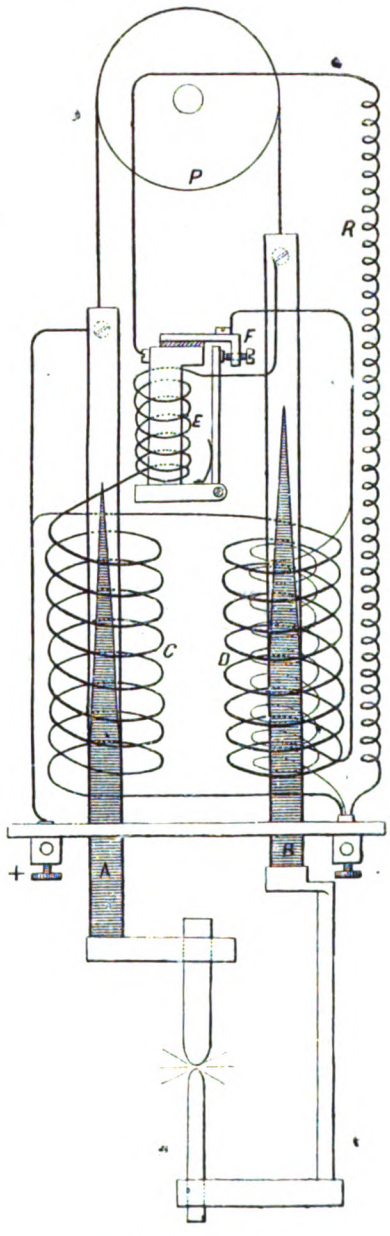

Fig. 21.—Pilsen Lamp.

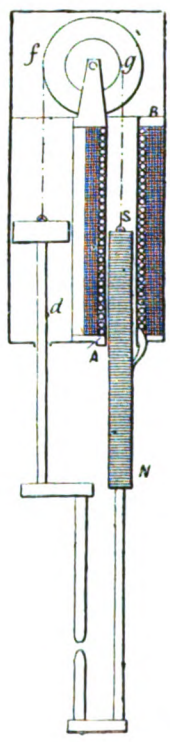

Fig. 22.—Menges Lamp.

magnetic clutch-wheels have been used by Dittmar (1886), and by Trott and Fenton (6910[84]).

Motor lamps have been devised from time to time, those of Tchikoleff, Schuckert, and Gray being perhaps the best until recently. The latest lamp of this type is that of Maquaire (1889). In this lamp there is a Pacinotti ring upon a vertical pivot, on which a worm is cut. This gears into a large wheel, the pinion of which drives the upper carbon holder by a rack. The motor ring stands between the polo-pieces of a powerful electro-magnet. By rotating it in one direction it strikes the arc; by rotating it in the reverse direction it feeds the arc. The direction of its rotation

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is reversed by reversing the direction of the current in it. This is accomplished in the following ingenious way. The coils of the electromagnet are in the main circuit; and from a point midway along these coils a branch wire goes to one of the brushes of the armature. The other brush is connected to the tongue of a sort of relay, and stands between two contacts, one of which goes to one end, the other to the other end of the coils on the electromagnet. By raising or lowering the tongue the armature is thus connected as a shunt, either to one-half of the magnet coils or to the other, the current in it being in opposite directions in the two cases. The tongue of the relay is controlled by a separate shunt coil, which attracts the tongue in order to feed the arc. The feed action of this lamp is extremely delicate.

(To be continued.)

SPECIFIC INDUCTIVE CAPACITY OF LIQUIDS.

Some interesting researches on the specific inductive capacity of liquids are described in a recent number of Wiedemann's *Annalen*.

Messrs. E. Cohn and L. Arons had previously carried out a series of researches on liquids whose conductivity did not exceed $4{\cdot}5 \times 10^{-13}$ in terms of mercury, and the specific inductive capacity was in every case found to be less than 5, so that the values obtained were of much the same magnitude as in the case of good insulators. The method used by them was founded on the result which they had obtained—that the dielectric polarisation and conduction are mutually independent, and involved observations of the rate of leakage of an electrostatic charge. The present research is concerned with liquids of a much higher conductivity, and a new method had to be devised, as the former one would have involved observations of time-intervals less than a millionth of a second. They therefore used a modification of Silow's method, founded on the principle that when a system of conductors immersed in a homogenous medium is maintained at a constant potential, the work done against electrical forces in producing a definite change in configuration is proportional to the specific inductive capacity of the medium. One terminal of an induction coil was joined to the needle and one pair of quadrants of an electrometer and the second terminal to the other pair. Readings were then taken alternately with air only, and with the given liquid in the electrometer, and in this manner it was found possible to extend the measurements to liquids as high as 16×10^{-10}, or some 3,400 times the highest conductivity to which the former method could be applied. Where K is the specific inductive capacity, and k the conductivity, the author found that for distilled water, for which k varied between $3{\cdot}4 \times 10^{-10}$ and 16×10^{-10}, K retained the constant value of 76. In the case of ethylic alcohol, containing 2 per cent. of water, the value of K was 26·5, which was not sensibly changed by the addition of traces of ammonic chloride, which increased the conductivity by $2{\cdot}3 \times 10^{-10}$ to 12×10^{-10}. When ethylic alcohol was added gradually to pure xylene K and k were both found to increase, but a change of k from 10^{-4} to 0·03 was only accompanied by a change of K from 2·36 to 3·08. These results show that for these substances Maxwell's law expressing the relations between the specific inductive capacity and the index of refraction is not even approximately true, the deviation being much greater than for glass and the fatty oils.

The author points out that it would be of great interest if it were possible to find some law connecting the specific inductive capacity of a substance with its chemical constitution. He suggests that this might possibly be attained by determining the specific inductive capacities of as many well-defined chemical compounds as possible, and of aqueous and alcoholic salts to as high a degree of concentration as possible.

Curiously enough, a Paper is contributed to the same number of the *Annalen* by F. Thomaszewski, in which he endeavours to obtain a solution of the question suggested by Cohn and Arons. The author considers the effect on the specific inductive capacity (1) of the number of atoms in a molecule requiring determinations of the specific inductive capacity of isomeric, homologous, and metameric compounds; (2) of introducing a fresh element into the molecule requiring determination of the specific inductive capacity of non-homologous compounds. These experiments were also carried out by a slight modification of Silow's method.

The values of the specific inductive capacity K, and of the index of refraction for an infinite wave-length μ, were determined for a series of isomeric compounds having the formula $C_{10}H_{16}$, and consisting of oil of citron and of oil of turpentine, obtained from different species of pines; and for a series of homologous compounds, consisting of the aromatic hydrocarbons, benzene, tolnol, paraxylene, and cumene. It was found that K was not constant for the different isomeric compounds, and in the case of the homologous compounds it was found to increase with the number of atoms in the molecule. Maxwell's relation $d = \sqrt{K}$, where d is the density, was found to be only approximately true.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March 16th*, 1889.

In my letter last week I made brief reference to the decision which has been rendered in Canada against Mr. Edison by the Commissioner of Agriculture, who also happens to be the Commissioner of Patents of the Dominion. The patent which has just been declared null and void is numbered 10,654, and was granted to Mr. Edison on November 17, 1879, for his incandescent lamp. On November 16, 1881, an extension of three months time within which to manufacture was given to the patentee, on his explanation to the effect that, having been engaged in introducing his invention in other countries, he had failed to manufacture in Canada within the two years prescribed by the law, owing to the large amount of capital that was required to establish the new industry. A petition to break this patent was brought by the Westinghouse, United States, and other interests about a year ago, and in the interval a large amount of evidence has been taken. It appears that on November 14, 1881, the Edison Electric Light Company did start a small factory in Montreal, worked by two men with an outfit worth about £400, and began the manufacture of lamps from the materials imported from the United States. The contention, however, was that the materials used were not raw materials in the rightful sense of the phrase, but were manufactured details of the complete lamp, and were simply assembled in Canada. With regard to this point, some of the witnesses for the defence stated that the carbon filament and the glass bulbs are exceedingly difficult to manufacture, and required great skill and judgment; that they could not be made in Canada; and that in point of fact there was only one factory in the United States itself where those lamps were made satisfactorily. This statement seems to have conflicted with the plea that these various particulars constituted raw material, and such a view of the case seems to have impressed itself upon the Commissioner, who calls the two statements irreconcilable. He says:—"The allegation of inability to manufacture in Canada is no plea in defence of the Canadian patent, and it would be a singular misconception of the spirit of the law if a patentee, probably holding a patent for his invention in the United States or other foreign country, should suppose he could hold to his Canadian patent, declare his inability to manufacture it in Canada, ignore the fact that he was thereby preventing anyone else from engaging in the industry, and defeating the very object and intention of the Patent Act, enacted to encourage and protect home labour and manufacture." The Commissioner further says:—"I find that every essential feature, element, and component part of the invention was, and still continues to be, imported into Canada by the respondents in a manufactured state, for the especial purpose of assembling or putting them together, so as to make them an incandescent electric lamp." On these grounds the Commissioner, therefore, declares the patent void, and he takes the trouble to say, with regard to the other point raised in the case—that of the refusal to sell the lamps except in conjunction with the other details of the Edison system—that even if he had pronounced on that point alone, it is more than probable that he would entertain a view adverse to that contended for by the respondents. It will be seen that this is an important decision with regard to incandescent interests in Canada, and it also appears open to inference that it may have important effects in this country, although this has been denied by the Edison Company. The recent decision of the United States Supreme Court in the Bate refrigerating case appeared to indicate that if a foreign patent should actually expire abroad, its expiration would limit the United States patent. The lifetime of such a United States patent is dependent on the expiration of the foreign patent rather than on the term for which the foreign patent was granted upon its face. Hence the point of the inquiry is shifted to the significance of the word "expiration," and as to whether this would mean a natural dissolution or a violent ending at the hands of the Court. It looks as though the Supreme Court would have to interpret its views a

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little more fully for the benefit of patent lawyers and an anxious public.

You will remember that I made the remark that although we were well through the first quarter of the year, nothing had yet been done with regard to carrying out the law inflicting sentence of execution by electricity in capital cases. This omission appears to have attracted attention, however, and during the present week we have had another series of experiments carried on by the indefatigable Mr. Harold P. Brown as to the effect of electricity on animals. In this instance the experiments of Mr. Brown, which were again made at the Edison Laboratory, were witnessed by some of the State officials. The animals experimented upon were dogs, calves, and horses. Nothing but the alternating current was used, and with it the dogs gave up the ghost at 500 volts, the calves at 800, and the horse at 1,000, after 25 seconds exposure. The law provides for the setting up of electrical apparatus for execution purposes in each of the three State prisons in New York State. As there are on the average not more than eight executions a year in the whole State, it is thought by some that this is rather an extravagant allowance, and it is urged that the apparatus should be kept in one place only, in some central location, not necessarily a prison. It is also urged that the apparatus, which it seems now pretty well settled, will be of the alternating character, should be placed in charge of a thoroughly competent electrician, for after all there is a very widespread feeling that this method must be applied with the utmost nicety and care. It is not yet known who is likely to secure the post, but in some circles it is expected that Mr. Harold P. Brown himself will be named as Lord High Executioner.

It is rather a striking commentary upon the legislation proposed in various States against the telephone companies that the law which was passed two or three years ago in Indiana, cutting down telephone rates has just been repealed. At the time of the passage of the Indiana law there was a very strong and bitter feeling in various parts of the State against the telephone companies. Their wires were ruthlessly cut in many places, their poles were chopped down, and they were ordered either to do business at a loss or to get out. They adopted the latter alternative, and the State was practically without a telephone service. The inconvenience soon began to be felt, for, after the telephone has been installed any length of time, its use becomes second nature, and its advantages are accepted almost as a matter of course. An interruption of the service, however, emphasises in a peculiar way its many advantages, and thus it happens that no sooner had the Hoosiers decided to do without the telephone than they began to want it back again. It is very much to be doubted whether the anti-telephone movement was strictly a popular one. It seems rather to have been worked up at first as a method of blackmailing the telephone companies, and having failed in that purpose, to have been used as a weapon of revenge. However, as might be expected, the good sense and intelligence of the people at last governed the situation, and there is every prospect that the telephone will soon resume its position in Indiana as one of the necessary comforts of life. It is to be feared, however, that this object lesson will be lost on many of our legislators, for in Illinois agitators have just succeeded in legislating for lower rates, and in New York the movement is still on foot, although the Hamilton Telephone Bill has been amended so as to fix the charge for New York City at $100 a-year. The rest of the State, however, is not affected by this amendment, but there is a saving clause to the effect that the telephone companies may make contracts for special work and for special service.

Boston has just been the scene of a very interesting discussion on the safety, economy, &c., of overhead wire systems for electric railways. This discussion was held before the Railway Committee of the Massachusetts Legislature, and arose out of a hearing relative to a measure granting permission to the West End Railway Company of Boston to run overhead electric railway conductors through the streets of Boston and elsewhere. It is understood that should the company obtain the consent it seeks, Boston will soon have over 200 miles of overhead electric railway system. It was natural that those interested in storage batteries and conduit systems would not be willing to allow so big a prize as Boston to slip through their fingers, and hence several of them appeared before the committee and made objections to the disadvantages of the overhead system as compared with the storage battery and the conduit. Mr. William Bracken, president of the Julien Company of this city, whose storage cars are running in New York, called attention to the work which is being done here, and insisted on the preferability of the storage car. He was supported by Mr. Ries, Dr. Vander Weyde and others, as well as by counsel representing remonstrant property owners, and was opposed by Prof. Elihu Thomson, Mr. C. J. H. Woodbury, Capt. Griffin, U.S.A., and others, who testified as to the general success of the overhead system, and as to the fact that the potential of 500 volts used so universally on that class of work is not at all one dangerous to life. There is said to be a likelihood that the West End Railway Company, which has been fighting for its case with a great deal of ability and energy, will get the permission it seeks; but it seems certain that no such comprehensive scheme of overhead electric railway conductors will be tolerated in New York, where the conduit system and the storage battery will have it all their own way unless they are forestalled by the cumbrous cable system. This remark does not, of course, include the elevated railroads, for we still have hopes of capturing these, and Mr. Daft is hanging on to the Ninth Avenue-road with a dogged tenacity worthy his British blood.

"The Efficiency of Methods of Artificial Illumination" was the title of a most able and interesting Paper read by Prof. F. L. Nichols, of Cornell University, before the American Institute of Electrical Engineers at its last meeting. In this Paper Prof. Nichols has taken up the subject of the light-giving value of different methods of illumination, and especially the incandescent lamp, with the object of determining the ratio of the light given to the total energy developed. In determining the relation between the luminous radiation and the total radiation of the incandescent lamp, Prof. Nichols cited the experiments of Merritt, who has determined these quantities in two different ways—in the one case by means of a glass calorimeter, in which the increase in the temperature of flowing water measured the heat developed, and in the other case by means of a thermopile which measured the heat radiated directly. The conclusions arrived at by Prof. Nichols would seem to indicate that the disparity heretofore supposed to exist between light-giving value and total energy between the arc lamp and the incandescent is not so great as was supposed when we consider the mean spherical intensity of illumination, although, when measured in certain positions this ratio may be as high as 6 to 1 in favour of the arc lamp; yet, considering the total illumination in all directions, that ratio hardly exceeds 2 to 1.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *March 26th*, 1889.

The erection of the Vienna-Prag telephone trunk line, and the decision to erect a telephone trunk line from Vienna to Budapest, has stirred up other towns to try and get the Government to erect similar lines to their towns. A deputation, consisting of the burgomaster and some delegates of the Chamber of Commerce of Pilsen, waited on the Ministry of Commerce, and asked that a trunk line be run from Vienna to Pilsen, at least from Pilsen to Prag. They were informed that the Government could not do this this year, but would take the matter into their serious consideration next year. The Chambers of Commerce in Trieste and Fiume have also petitioned that a trunk line be run from Trieste, the only Austrian large commercial port, to Fiume, the Hungarian port. Both the petitions from Pilsen and Trieste were supported by the Telephone Company of Austria, who have exchanges in these towns. The Government also propose running a short experimental line over one of the worst parts of the Karst, a bare mountain region between Laibach and Trieste. This line is to be built of silicium bronze wire, and specially constructed to resist the snow and ice, which in that part have hitherto devastated the telegraph lines every year. Should this line stand the winter there, the idea of connecting Trieste with Graz and Vienna will probably be realised.

The Austrian telegraph service enjoys a special reputation for building good overland lines, and they are doing their utmost to so

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construct the new line to Prag that no defects should crop up. Much thought and care has been bestowed on the joints, and the joint adopted is really the most perfect I have seen. The poles have been carefully selected, and the way the wires are to be crossed is as simple as it is ingenious. I hope at some future date to to able to send you a description of these crossings.

CORRESPONDENCE.

THE FRITSCHE DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your "Notes from Germany," *Electrician*, March 8, 1889, you mention a new dynamo made by Fritsche and Pischon, of Berlin. Please allow me to say that this machine is a direct infringement of our patents. In *The Electrician* of June 10, 1887, a full description of our Faraday disc machine was given, and in which the vital principles were described, viz.:—

"It will be seen from this construction that every coil has the same area, and each and every coil is so divided that one-half is in the inside of its neighbouring turn while its other half is on the outside of this neighbouring turn; also, that one-half of every turn is on one side of the armature while its other half is on the other side. It must be understood that this construction is not a simple overlapping of coils, which would cause an oblique or sloping position, but is a mode by which each half of the coil lies in a different yet parallel plane.

As is known, we make our coils out of metallic strips or bars, as is shown in *The Electrician*, June 10, 1887, Figs. 2, 3, 5, 7. It can easily be seen that it makes no difference if instead of taking a strip or bar, as we do, and dividing it into two parts, as shown in the above-mentioned figures, we take two parts and solder them together to make the same piece, which could have been made direct. We have seen the German patent of Fritsche, No. 45,808, and it contains only one meagre claim for a winding, which in reality is nothing but a zigzag winding, and which zigzag winding we also use in our machines, and which is also shown in *The Electrician* of June 10, 1887, Fig. 10.

You will remember that we sent you about a year or so ago a monograph of our iron Faraday, in which the armature is entirely made of iron. Such a monograph was also sent last year to Siemens, of Berlin.

We therefore invite Messrs. Fritsche and Pischon to show where the new idea of their machines comes in, and where there is not a direct infringement of our rights.—Yours, &c.,

JEHL AND RUPP.

Am Kiosk 7, Brünn, March 21, 1889.

THE CENTRAL LIGHTING STATIONS OF FRANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read in the issue of 15th inst. of your esteemed journal a list of Central Lighting Stations of France, compiled from a Paper read by Mr. Aimé Witz and enlarged and revised by your Paris correspondent; but to our great surprise we find that both Mr. Witz and your correspondent have neglected to complete that list by mentioning the central lighting stations made by our licensees in France with Zipernowsky-Deri-Blathy alternating current-transformers, and we therefore take the liberty of giving you the following specification relating to the said plants:—

Towns.	Output in lamps.	Distribution.
Reims	300	Overhead.
St. Tropez	200	,,
Rives	300	,,
Valréas and Dieulefit	600	,,
Dijon	900	,,
Grenoble	900	,,

The central station for the lighting of the two towns of Valréas and Dieulefit is erected at Become,—Yours, &c.,

Budapest, March 19, 1889. GANZ ÉS TÁRSA.

BOOKS, &c., RECEIVED.

The General Electric Company's Illustrated Catalogue of Electric Bells, Telephone and Telegraph Apparatus.

"Electricity in the Service of Man." Part I. From the German of Dr. A. R. von Urbanitsky. Edited by R. Wormell, D.Sc., M.A. (London: Cassell and Co.)

"*Proceedings* of the Royal Society of Edinburgh." Vol. XV., Nos. 126 and 127. (Edinburgh.)

"The Gas Engineer's Annual and Gas Companies' Directory for 1889." (Birmingham: John Wright and Co.)

"Lists of Electric Tramways and Electric Welding Apparatus." (Boston: Thomson-Houston Company.)

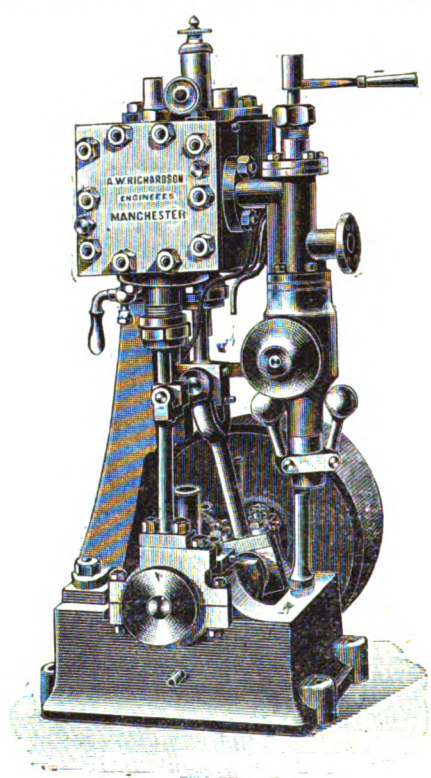
"South Africa, and How to Reach It by the Castle Line." By EDWARD P. MATHERS, F.R.G.S. (London: Waterlow and Son.)

"L'Electricité à la Maison." (Paris: J. B. Baillière et Fils.)

"Directory of the Lancashire and Cheshire Telephonic Exchange Company." (Manchester: George Falkner and Sons.)

THE RICHARDSON HIGH-SPEED ENGINE.

This engine, as illustrated, has been specially designed for dynamo driving direct, or by belt or ropes. It is also adopted for driving centrifugal pumps, fans for forced draught, and for any purpose where great power and high speed are required in a small space. It has been constructed with great care to run at high speeds with safety and economy, and without excessive wear. The crank is made of mild steel, carefully balanced. The cylinder and upright are cast in one piece. The cylinder is steam-jacketted, and is fitted with a liner, which with the valve face can be at any time removed.



The piston rings and valve are of phosphor bronze. All bearings are extra long, and are made of phosphor bronze or best gun-metal. The crank shaft bearings are fitted in square, with wrought-iron caps. The glands are specially constructed for tightening whilst running without the risk of jamming on the rods. The governor is of the high-speed class, and is very sensitive, and can be adjusted whilst running. All forged parts, bolts, studs, and nuts, are made of mild steel. All parts are made to template, and are interchangeable. The lubricating arrangement is well adapted for long and continuous running. The most practical way of driving dynamos on steamships and other confined spaces is by small high-speed engines coupled direct. These engines take up little room, as they can be fixed on the same bedplate as the dynamo. They are made inverted and horizontal, double and compound, in sizes from 4½ to 60 indicated horse-power. Engines of this class can be fitted with automatic expansion arrangement if required. The maker is Mr A. W. Richardson, of Stretford-road, Manchester.

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PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

February 18, 1889.

2,854. D. URQUHART and W. BATES. London. Improvements in electric-light fittings.

February 19, 1889.

2,885. R. H. C. NEVILLE. Grantham. Improvements in methods and apparatus for charging secondary batteries or electrical accumulators.

2,906. R. H. COURTENAY. London. Improvements in micro-telephonic apparatus, which improvements consist partly in the use and employment of fluids as a medium to impart vibratory motion by means of sound and currents of electricity.

2,943. S. D. WILLIAMS. Newport. Improvements in dynamo-electric machines.

2,949. E. D. CROSS. London. Improvements in galvanic batteries.

2,952. H. H. LAKE. London. Improvements relating to the transmission of electro-magnetic impulses for telegraphic and other purposes (C. E. Dressler, United States).

2,957. A. WILSON and L. CLARK, MUIRHEAD and Co. (LIMITED). London. Improvements in underground conduits and insulators for electrical mains.

February 20, 1889.

3,022. R. COTTERELL. Glasgow. An improved telephone mouth-piece.

3,036. A. J. BOULT. London. Improvements in electric signalling apparatus for railway trains (W. C. Johnston, junior, United States).

February 21, 1889.

3,089. G. PRINCE and J. WATKINSON. Leeds. Electrical signalling, self-acting and otherwise, on a railway.

3,103. W. HIBBERT. London. Improvements in electrical measuring instruments.

3,130. H. FRASER. London. Improvements in or connected with gear wheels and bearings for magneto-electric call-bell apparatus for telephonic instruments; applicable also to other mechanism.

February 22, 1889.

3,163. F. T. SCHMIDT. Bradford. Improvements in electrical call-box apparatus.

3,213. W. E. AYRTON and J. PERRY. London. Improvements in measuring instruments and electrical appliances.

February 23, 1889.

3,263. G. RICHARDS. Manchester. Improvements in the mechanical construction of electrical dynamos.

3,272. W. P. THOMPSON. Liverpool. Improvements in or relating to electric motors (The Westinghouse Electric Company, United States).

February 25, 1889.

3,324. F. T. SCHMIDT. Bradford. Improvements in the method of and apparatus for operating the carbons of arc lamps.

3,327. W. BALLARD. Worcester. Signalling by electricity on railways by means of the train in motion.

3,330. J. HARTNESS. Newcastle-on-Tyne. Improvements in the application of the electric incandescent light, to be used by man or beast.

3,345. J. CLEGG. London. Improvements in electric light emitting and other conductors.

3,350. Sir C. T. FORBES, Bart. London. An improved instrument for measuring currents of electricity.

3,363. J. W. EDMUNDSON. London. Improvements in the manufacture of incandescent electric lamps.

3,365. LEO. KAMM. London. Improved apparatus for facilitating the laying of electrical conductors, chiefly designed for military purposes.

3,373. A. D. MUNRO. London. An improved acoustic galvanic apparatus.

February 26, 1889.

3,396. F. E. MACMAHON. London. An improved electric checking apparatus for beer engines.

3,401. E. A. SPERRY. London. Improvements in or connected with current regulators for dynamo-electric machines.

3,402. W. H. SCOTT and L. PARIS and SCOTT (Limited). Norwich. Improvements in apparatus for metering electric energy.

3,420. J. SAYERS. London. An improved method of automatic regulation in dynamo machines.

3,424. J. SWINBURNE. Chelmsford. Improvements in dynamo-electric machines and motors.

3,456. S. C. C. CURRIE. London. Electric circuit couplers.

3,451. F. V. MACQUIRE. London. Improvements in and relating to electric regulators or balances.

3,499. A. MECHAN. Glasgow. Improvements in electrical telegraphs for use on board ship.

3,540. J. HUNTER. London. Improvements in electric danger alarms for railway block signals.

February 28, 1889.

3,552. W. ROWBOTHAM. Manchester. Improvements in holders for incandescent electric lamps.

3,556. O. FIRTH and E. W. CRABTREE. Bradford. An improved method of regulating the current developed by dynamos or magneto-electric machines, and the power of electric motors.

3,558. H. KENYON. Liverpool. Method of obtaining aluminium continuously in an electrical furnace.

3,569. J. J. BOWMAN and V. G. LIVONI. Leytonstone. Electrical measuring instruments.

3,580. F. H. BERRY. London. An improved electric bell or gong.

March 1, 1889.

3,629. R. SNOWDON. Manchester. Improvements in electric meters.

3,652. T. A. B. PUTNAM. London. Improvements in electric railway signals.

3,671. A. J. BOULT. London. Improvements in or relating to winding and synchronising clocks by electricity (R. J. Pouchard, France).

3,674. C. D. ABEL. London. Improved method of and apparatus for distributing and regulating electric currents (the firm of Siemens and Halske, Germany).

3,679. H. H. LAKE. London. An improved apparatus for regulating electric currents and for other purposes (E. Thomson, United States).

SPECIFICATIONS PUBLISHED.

1888.

1,364. MARTIN. Driving Dynamos. (Price 6d.)

4,153. KING. Regulating secondary current derived from continuous transformers. (Price 8d.)

4,345. KAPP. Distributing electrical energy. (Price 8d.)

4,604. PYKE and BARNETT. Continuous opening and closing of electric circuits. (Price 8d.)

5,182. STONE and GILFILLAN. Telegraph transmitters. (Price 8d.)

5,922. STUART. Joining electric conductors. (Price 8d.)

14,100. VAIL and SEELEY. Telephone central-station apparatus. (Price 8d.)

14,111. VAIL and SEELEY. Telephone exchange signalling. (Price 8d.)

15,369. FICHET and NODON. Secondary batteries. (Price 6d.)

1,926. BRAUN and LLOYD. Mechanical chair for delivering a current of electricity on insertion of coin. (Price 8d.)

2,125. ROWBOTHAM. Arc lamps. (Price 8d.)

1889.

30. DEWEY. Electric Telegraphy. (Price 8d.)
Second Edition.

1879.

315. JOHNSON (GOWER and ROOSEVELT). Transmitting, &c., articulate sounds. (Price 8d.)

394. JOHNSON (GOWER and ROOSEVELT). Telephones. (Price 8d.)

1887.

15,484. CARDEW. Safety devices for electric circuits. (Price 8d.)

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The thirty-first ordinary general meeting of the Company was held at Winchester House, Old Broad-street, on the 25th inst., under the presidency of Sir James Anderson.

The MANAGER (Mr. Charles Gerhardi) read the notice convening the meeting, and the minutes of the last meeting having been read, were signed by the Chairman as correctly entered. The report of the Directors was taken as read.

The CHAIRMAN: I have very little to say on this occasion. Curiously enough, as I sat in the adjoining committee room three minutes ago, I looked over what I said at our last half-yearly meeting, and to my no little surprise I found that I had used almost the very same words that I was going to say to this meeting. I said at that meeting:—"We have carried 2,000 more messages in the last three months than in the corresponding three months of 1887; but we had not earned so much money." I was going to say to you now that we have carried 2,000 more messages in the half-year under review but 27,000 fewer words than in the corresponding half year of 1887. The average length of the telegrams has fallen about three-quarters of a word. We are face to face with a natural desire of all merchants to economise all the money they can, and to make their telegrams as short as possible. I do not know what they are going to come to, but it is quite obvious that if they go on reducing the length of the messages to, say, only one text word, it will be impossible to pay anything. I find on investigation that there are an enormous number of telegrams sent to the East consisting of three or four words only, and a three-word message does not pay at all. Whether anything will be done to alter that at the conferences I cannot say, but it is remarkable that whenever I come before you I have to say the same thing—that the messages are getting shorter and shorter, and that while we are carrying more of them we are getting no more money. There is a decrease of

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£305 in the traffic receipts compared with those for the corresponding period of the previous year. That, however, is not owing to a falling off in trade generally, but through the failure of the fruit trade. This year the fruit was as bad as it could be, and it nearly all went rotten at sea. Formerly this would have been a more serious matter with us, because a few years ago the telegrams were all about fruit and shipping, but now, since the Commercial Treaty was framed, we have a more miscellaneous class of messages. You see by the report that we have had a break in our Bilbao cable since the date to which the report refers. Fortunately for this Company, the Eastern Telegraph Company had a ship at Lisbon, and she was able to get on the ground in three days from the time the break occurred, and, although the weather was very bad, she effected the repairs in sixteen days, curiously enough the time it took to repair the former break. I have on the table a piece of the broken cable. It was down 1,£00 fathoms, and you will see that it was literally torn asunder by a landslip. Evidently a mountain of mud fell down and wrenched the cable in two. I do not know how we are to avoid these sort of breaks. We have had them again and again in various parts of the world, and we cannot find any way of getting over them except by repairing them. The cost of these late repairs was £2,966, and we deal with that by carrying forward £723 out of revenue this time, and you will pay the balance partly out of revenue and partly out of reserve next year unless we have another break next time, though I have no reason to apprehend anything of the kind. I am glad to be able to tell you that in spite of the sixteen days' interruption—in consequence of which we lost some of the traffic, though not all, because we have a joint-purse arrangement with the Eastern Telegraph Company—we have earned £250 more this quarter than we earned in the corresponding period of 1888. I have nothing more to say unless you ask questions to which I can reply. We are going on successfully, and Mr. Gerhardi and all our officers are doing their best to foster and increase the traffic by visiting the stations and the provinces, and at the present moment we are doing as well as we can very well expect. With these remarks I beg to move—

"*That the report and accounts now presented be and the same are hereby received and adopted.*"

Mr. EDMUND ETLINGER seconded the motion, which was carried unanimously.

The CHAIRMAN: I now propose—

"*That the dividend at the rate of 10 per cent. per annum less income tax on the Preference Shares, and a dividend at the rate of 4 per cent. per annum free of income tax on the Ordinary Shares, both for the half-year ended December 31st, 1888, be and are hereby declared.*"

Mr. ETLINGER seconded the motion, which was carried unanimously.

Continuing, Mr. ETLINGER said: The next resolution refers to the re-election of retiring Directors, and I have very great pleasure in proposing the re-appointment of Sir James Anderson. That is a motion which hardly requires any further remarks from me.

Mr. JOHN DENISON PENDER seconded the motion, which was carried unanimously.

The CHAIRMAN: I am obliged to you for your confidence. I am very glad that we are in the saddle, because it is a great matter for us to be able to use the ships of the Eastern Telegraph Company and of all the other companies with which we are connected. That saves us a good deal of money. I have now the pleasure of proposing the re-election of Mr. Denison Pender.

Mr. ETLINGER seconded the resolution, which was carried unanimously.

Mr. PENDER having acknowledged his re-election,

Mr. JOHN GLOVER proposed, and Mr. W. B. COCHRAN seconded, the re-election of the auditor, Mr. Herbert R. Duke, which was unanimously carried.

Mr. COCHRAN: Are you quite satisfied with the character of the Bilbao cable?

The CHAIRMAN: Yes; nothing stronger could be made in the world.

On the motion of Mr. COCHRAN, seconded by Mr. JOHN NEWTON, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN: Though we have not much to say at these meetings, we give a great deal of anxious thought to your affairs and in devising what we can do to economise and to increase the traffic. I think it most fortunate that Mr. Gerhardi and I came together five or six years ago and resolved on a joint-purse agreement, which has made it better for us all round.

The meeting then separated.

The Submarine Telegraph Company (Limited).

An extraordinary general meeting of this Company was held on Monday at the offices of the Company, 2, Throgmorton-avenue, London-wall, for the purpose of considering the offer of the French and English Governments to purchase the Company's cables between England and the Continent. Sir Julian Goldsmid, Bart., M.P., presided.

The SECRETARY (Mr. S. M. Clare) having read the notice calling the meeting,

The CHAIRMAN said: Ladies and gentlemen, I am afraid that I shall have to trouble you at considerable length in order to give you a full account of the state of affairs with which we have at present to deal, and as I am suffering from great hoarseness I am sure you will give to me your indulgence. I must take you back to the 16th of July, 1878, the date at which we made an agreement with Lord John Manners, who was then Postmaster-General. That agreement, besides providing for giving the proportions to the Post Office of the receipts which came in from the telegraphic communication with the Continent, also contained a very important clause, which has been mentioned to you before, but on the present occasion I consider it necessary that you should have the whole case before you, in order that you may arrive at a satisfactory conclusion, and therefore I will read the clause now. It is Clause 8 of the agreement, and is as follows:—"This agreement shall take effect from the 1st of January, 1879, or so soon after that date as the French and Belgian Governments shall have granted a renewal of the concession to be applied for, and shall remain in force until the 31st December, 1898; but no alteration of the existing tariff shall take place unless and until this agreement shall come into operation." Well, that was signed and sealed on the 16th of July, 1878.

A SHAREHOLDER: At what date does it expire?

The CHAIRMAN: If it had come into force it would have gone up to 1898, but as it has never come into force the only part that is material is the date at which it was made. My predecessor, the late Sir James Carmichael, forthwith made application to the French Government, which was always considered the leading Government with regard to the arrangement between the Post Office and the Submarine Telegraph Company, to give them a renewal or extension of the concession which, as you know, expired early this year. The French Government upon that occasion and in three subsequent years absolutely refused to do so, because, they said, the application was premature. They said that the time which had still to elapse before the end of the concession was too long, and they therefore declined to consider the question. So matters went on until three years ago, when I thought I would make a determined effort to obtain a renewal of this concession in order to put this agreement which I have read to you—which was practically a draft agreement—into force. Without going through all the events of those three years, I may say that we negotiated with four successive Ministries, and that practically three of them nearly came to a conclusion. The last Ministry of all with which we negotiated was the Ministry of which M. Rouvier was the head, and he was particularly capable of considering this question, because he had attached to his own department of Finance the Telegraph and Post Office Department, which had been previously a separate one, with a separate and independent Minister. The result of the efforts made by many of the Directors was this: M. Rouvier informed us in writing that he was prepared to grant a renewal of the concession for 10 years, and then occurred what has also been mentioned to you—a diplomatic Note on the part of Her Majesty's Government, in which they requested the French Government not to grant a renewal of that concession. Well, we maintain that under the agreement with Lord John Manners they had no right to do so, but their argument was that as a reasonable time had elapsed since the signing of that agreement, and no renewal of the concession had been obtained under this Section 8 to which I have referred you, they were no longer bound by an agreement which had not been put in force. The policy of the Government had changed, and they had, therefore, determined to make arrangements with Foreign Governments by which all the telegraphic communication between England and France, England and Belgium, England and Holland, and England and Germany, should be in the hands of the respective Governments. We thought that, considering that agreement very hard upon the proprietors of the Submarine Telegraph Company, who had been led to believe, as we had been led to believe, that we should in all probability obtain a renewal of the concession, and I have pointed out to you as clearly as I can the reason why we considered we had a right to expect a renewal of the concessions if the French Government and the Belgian Government were willing so to renew them. But the position at this date eighteen months ago was practically this:—We had obtained this promise of renewal, and that promise was about to be carried into effect when the English Government prevented its being carried into effect. Then they made arrangements with the French Government by which they should jointly acquire the cables between France and England, and Belgium and England, and they also made arrangements with the German Government by which one cable which belonged to England should remain in the hands of England, so that there again the communication between Germany and England should be divided between the two countries. That leads me to a point with regard to the German Union Telegraph Company. That company had a concession which was not an exclusive concession, and there were still, I think, about eleven or twelve years of it to run. That concession not having been exclusive, it would have been possible for the German Government to lay down other lines, or to make arrangements in some other way with the German Union Telegraph Company. As they decided that it was desirable to take the telegraphic communication into their own hands, they gave notice to the German Union Telegraph Company, and the result of that was that they came to an agreement with the Directors of that company by which they refunded the capital of the Company, with a bonus of 25 per cent. upon it. In some of the communications that we have had with the Government we have pointed to that as an example that might be fairly followed in the case of this Company; but they did not appear to see the argument exactly in the same light in which we saw it. Then came the question what was to be done at the end of our present concession. We had frequent interviews with Her Majesty's Government, who were authorised and requested by the French Government to carry on negotiations with us on behalf of the Governments concerned, and the sum and substance of the proposals made by the Chancellor of the Exchequer and Mr. Jackson, Secretary of the Treasury, on behalf of the Government, was this originally, it was that we should sell to them the French and Belgian cables at a valuation price, the valuers being appointed one by the Governments, one by us, and an arbitrator in the usual manner. That was a proposal which is well known to everybody connected with English law, and which is in itself so fair, was one which recommended itself to us for which we were prepared to accept, and that was perhaps the very first point on which we easily came to an agreement, and which we understood to be settled and done with. Then you can imagine our surprise when only about three months ago we were informed that the French Government had decided that they would have nothing to do with this

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method of valuation, and that they must have some other system adopted, which other system we fear will be less satisfactory to the shareholders of this Company, and less fair from our point of view. After negotiations, which were again of a protracted and troublesome character, it was finally decided that the Governments were to appoint officers to test the cables to ascertain exactly their electrical condition, and that they should make an offer based upon the results at which they had arrived in consequence of that test. Well, they set officers to work, and the French officers applied to the cables tests which, I think I may fairly say, were not such as should have been applied, and such as are only applied in the case of cables in the course of manufacture in the laboratory, and not to cables which have already been working for some period of time at the bottom of the ocean. Our contention has always been that the value of a cable as a commercial investment is its practical efficiency. On that point I think I ought to say a word or two, because allegations have been made with regard to the condition of the cables which very seriously affect the question. You must be aware that the cable which is at the bottom of the Channel is not in the same position absolutely or relatively as a cable that is at the bottom of the Atlantic, or any other deep ocean, because it is liable to fracture and danger by the anchors of fishing boats and in many other ways, to which cables at the bottom of a deep sea are not liable. The fact is notorious. For example, on one occasion a fishing boat in stormy weather brought up with its anchor one of our cables, and being in a hurry to get away the skipper did not take the trouble to unfasten the coil round his anchor but chopped it in two. Then, of course, the two ends sank to the bottom of the sea. The result of that was to proceed to mend the cut ends. It is not always easy to find the authors of such a proceeding. That, therefore, shows the point to which I wish to come, which is that a cable, however good, must be repaired frequently when it is at the bottom of the Channel, whereas if it is at the bottom of the ocean it may be quite undisturbed, and the result of that is that no cable is entirely free from constant repair. During the last decade—or rather during the last five years—the cables have not been repaired so frequently as they had to be during the previous period of ten years, but taking the same relative proportions during the last five years, the cables appear to have been more free from accident than they did at the two previous periods of the five years. It is a curious circumstance, and shows that age has nothing to do with it, but that accident has much to account for. The result of the testing of the cables was this, that allegations were made that these were patched cables, which of course I have explained must of necessity be the case, and that, in addition, the officers did not consider that those cables were in an electrically perfect condition. We have pointed out that as far as the cables are concerned they practically do the work very well without any impediment to traffic, and consequently they are in a perfect condition from a business point of view. Anyhow, the result of that proceeding has been that we have had two letters, which I shall now call upon the Secretary to read, and then I shall proceed with my statement, and give you the rest of the information upon which you will have to give your opinion.

The SECRETARY here read the letters addressed to the Company by the authorities of the Post Office with respect to the conclusions which the Governments of France and England had arrived at as to the value of the Company's cables.

The CHAIRMAN, commenting upon the various letters, said: Those letters were immediately brought before the Board, and we considered the matter of such importance to the shareholders of this Company that we decided to immediately call a meeting of the chartered Company and a meeting of the shareholders of the French Company, in order that we might lay the whole of the business before them, and I forthwith informed the Chancellor of the Exchequer that that was the case, and that we had fixed on the earliest date to hold such meetings, and that until those meetings we could not give a definite reply, and that therefore we must ask the Governments to be good enough to extend the time for settling matters in order to lay them before the proprietors. You will expect from me some information with regard to the value of cables calculated to do the business which has to be done and has been done by the cables in question. There are four cables belonging to this Company which are now at work between England and France. If you had to lay down four new cables over the same areas Mr. Clare's estimate is that they would cost the sum of £59,385, and the cost of two new cables to Belgium over the same lines would be £33,678, so that those six cables would cost £93,073. Now, the Government offered for the four French cables, first, £11,300 and 10 per cent. added, making £12,430, and for the two Belgian cables £9,000, with £900 added, making £9,900, and the total of these sums would be therefore £22,330, or, as you will see, 25 per cent. of the actual cost of new cables. With regard to the six cables belonging to this Company with which we have to deal, there is therefore an offer of £22,300 on behalf of the Governments. I have to say that, as the result of an interview that several of us had with the Chancellor of the Exchequer, he has authorised me to say that any sum that was finally agreed upon to be paid would be handed over by the English Government direct, and that they would afterwards arrange with the French Government. Then I wish to point out to you that the cost of new cables is four times as much as the price that is offered to us for these old cables. We have always calculated that under the worst terms of a valuation by arbitration, to which reference was made by me in an early part of my speech, and which was originally agreed to by the Government, would have given us at least 50 per cent. of the cost of new cables; and some of us thought that the sum given us would reach 75 per cent. Consequently you will see that from that point of view we are offered a very small proportion of the value of new cables. Well, now, I ought also to put before you another aspect of the question, which is not, of course, quite so important, but which, I think, ought to be communicated to you. The French cables really earned in the past half-year about £28,900, and the Belgian cables earned about £11,930, making altogether £40,830, and if we take off £17,000, roughly, for working expenses, we are left with a net income of £23,830. You will therefore see that in six months the net income of the cables is a little more than the price offered to us for the means of earning it. Therefore, from that point of view the Government would certainly be making a very good bargain. The question then arises—Ought we to accept this offer or ought we to reject it? If we accept it what will happen? If we reject it what will happen? Upon this point I ought to say that if there has ever been a difference of opinion between myself and any of my colleagues I believe it has been more as to the advice that we should give to you on this matter than on anything else, and I think you will understand that we have found ourselves in a most difficult and more embarrassing position. I have had much business to transact in the course of twenty-five years during which I have been connected with companies, but I have never had so much trouble or anything which has given me so much anxiety as the negotiations with regard to these matters, which have been attended to by myself and every one of my colleagues, I will venture to say, as if they personally concerned ourselves rather than if they concerned a body of shareholders. I may say that on behalf of my colleagues as well as on my own we have done everything that we could in any way to promote the interests of the shareholders. If we have to lay this unsatisfactory state of affairs before you I assure you it is not owing to any lapses on our part, but owing to the inherent circumstances of the case over which we have no control. We are asked to take for those cables a sum which we certainly consider to be considerably below their value. Then there are left to us two other cables which are part of our property, namely, the cable which is leased by the Paris and New York Telegraph Company, and which, under the agreement, we have every reason to believe that they will purchase at a sum of about £11,000; and then we have another cable leased by the Anglo-American Company; but I do not wish to say anything further with regard to these two cables. What I am referring to is the offer of the Government for the cables with which we have now to deal—the four to France and the two to Belgium. If we decline the offer made to us, I must put before you what, in my opinion, is the position of affairs. We are told that the French Government are anxious to lay down altogether new cables, and that in their opinion they think it would be better to begin business by doing so and not by purchasing our cables. Of course, in that case, at the lowest valuation—and our estimates are low and reasonable—the French authorities would have to spend their share of some £60,000, instead of paying only the very small sum which is offered to us; but they would have new cables instead of our cables, which we believe to be perfect instruments for many years to come. I have pointed out to you that new cables may be broken as well as old ones. Now, then, there is this chance, that if you refuse this offer that the two Governments may say that they won't have our cables at all. In that case of course the cables would be worth only their picking-up value, whatever that might be. That is a very serious consideration, which the shareholders must carefully weigh. You may fairly ask us at this point, have we done our best and our last in order to induce the Government to consider whether they cannot make us an offer more adequate, more suitable to the occasion, because we have pointed out to them that they are obtaining an instrument by which they will earn an income for the country which is known in no other Government investment, and which ought, therefore, to allow them to deal, I will not say liberally, but justly, with the shareholders of this Company? We have done our very best in this direction, and some of us flatter ourselves that we have produced some slight impression upon the heart of the Chancellor of the Exchequer, which may be stony, but which I cannot help hoping in this case may not be so. My colleagues and I have urged upon him to really examine these points, which I have ventured to put before you in as clear a manner as lies in my power, in order that he may see that we are not getting a reasonable price for our property. Though I have no right to say so, I have still some hope that there may be an improvement in the offer made; and, consequently, if you ask me what you had better do under all the difficulties of the situation I should advise you to pass something of this kind, which I have carefully considered, and which I believe meets the best view of the circumstances of the case. It is this:—"That the Directors be requested to inform the Government that, in the opinion of the shareholders, their offer of £22,330 for the purchase of the Company's cables between England and France, England and Belgium, and Jersey and France, is far below their value; that the Directors be authorised to allow the Government to work the cables on and after the 1st of April next, to continue their negotiations, and to conclude the sale of the cables to the Government at the best price they can obtain, and that the Directors inform the proprietors by circular, as soon as possible, of the result of their further negotiations." Why I ask you to give us this authority is, as I said just now, that I hope that the Chancellor of the Exchequer will be persuaded to point out to the French Government that they ought to give us something more than the amount referred to. But, in my opinion, and in that of the majority of my colleagues, it is desirable that you should authorise us to conclude this matter in order to avoid greater risks and greater dangers which might fall upon you. The latter part of the motion has reference to allowing the Government to work the cables on and after the 1st of April next. One of the conditions that the Government proposed was this, that they should have the right to come into these premises, take over our staff and the work, and they offered and agreed to give us 4 per cent. upon the amount which they may have to pay us up to the date at which they pay us. I may say that the Government of England are taking over a great deal of property which does not concern the Government of France in any way. They are going to take this house, all our stores, our steamboat, our country places—I mean our stations where we have the landings of our cables—in fact, they are going to take over everything used for the working of the business, and, what is the most important thing of all, they are going to take our staff with very few exceptions. With regard to the staff, which is a matter which greatly concerns the

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shareholders—and, I think I may say with some pride, that the best relations have always existed between the staff and the Directors who have represented the shareholders—I think the staff have been of opinion that the Directors have endeavoured to look after their interests as well as those of the shareholders; and I believe that a good state of feeling between the staff and the Directors representing the shareholders is the very best and only condition which ought to exist in a company like this—in looking after the interests of the staff we have been very anxious that no man, if possible, should lose his berth. We thought that the shareholders would be of that opinion, and the result of our negotiations has been that with some exceptions the whole of the staff will be taken over by the Government. Then we naturally asked, What will you do with those of the staff that will not be taken over? Mr. Clare is one of these, and a few others. After some discussion they agreed to give two years' salary as a bonus to each of the officers who did not pass over to the service of the Government provided that the amount so paid did not exceed £5,000. We made a representation to the Government the other day that the officers who have to retire would require a sum of something like £5,800 in order to receive their two years' salary, to which they would under this arrangement be entitled, and we asked the Government to extend their proposal to that amount. They have extended it to £5,500, but they said no further, and consequently I shall have to ask you to give us the other £300, or to authorise us to pay it out of the funds of the Company, and I am quite sure the shareholders will say that this allowance should be made to the officers who will not be taken over by the Government. That is the exact position of affairs. I have now to give you a little information with regard to the Calais cables which belongs to the French Company. That was the original cable which did business between England and France, and according to the tests of the French officials that was the best cable of all, thereby contradicting that allegation that it is age which incapacitates a cable from doing its work, and confirming very largely the statements which I have made on several occasions, that the value of a cable between England and France does not depend upon its age so much as upon the absence of interruptions to which it may be subjected by ill-treatment. It is like everything else—a question of treatment. Therefore, the Government say that they are willing to give more in proportion for that cable than for any of the others. That matter will have to be considered by the French Company on Saturday next, but the course you will adopt to-day will mainly guide the French Company in what they should do, and consequently your decision is of great value and importance from that point of view. I will sum up the position in this way. You are offered the sum of £22,330, to take or to leave it, unless we can induce the Government somewhat to improve that offer, as we have still hopes of doing: and I suggest to you that you should give us authority to conclude the matter even for that miserable sum, if it is absolutely necessary, and I put it on the ground of fairness and justice, and of the value of the property as an income-earning machine, to the Government that they ought to give us more. That is the exact position of affairs, and I shall either move this resolution myself if you think it is desirable that I shall do so, or I shall ask some shareholder to move it in order that it may be before you for your acceptance or refusal. If the shareholders reject it it will devolve upon them to decide what course we shall follow under the very difficult circumstances of the case.

A SHAREHOLDER seconded the resolution.

Mr. ROBINSON said that he was very much surprised when he received the notice of the meeting that the Board did not inform the proprietors of the amount which the Government offered. He was sure that all the shareholders were very much astonished at the ridiculously low sum which was offered to the Company. He would also like to ask what position they would be in if they refused to carry the Government messages. Could they not put the screw upon them and put them to very great inconvenience by refusing to carry their messages after the 1st of April? After the way in which the Company had met the wishes of the Government in times past they ought to have met the Company in a more liberal spirit.

Mr. RAINES asked what would be the picking-up value of the cables, supposing the Company refused the offer of the Government, and also whether the Company's other property was to be valued on the same scale as the offer for the cables.

The Hon. H. R. BRAND, in reply, said that the answer to the first questioner must be obvious, that the Company had a duty to the public as well as to the Government, and that it would be most fatal to their interests to place themselves in a position so invidious as that suggested applause. The Chairman had already told them that it would cost about £93,000 to lay new cables, and that they were offered £22,330, while they would have considered that the price offered to them would not have been unreasonable if they had obtained for their cables 50 per cent. of the value of new ones: therefore the sum in question was somewhere about £25,000. He did not think that it would pay the cost to pick up the cables.

Mr. LEWIS suggested that it might be *ultra vires* to enter into any bargain such as that proposed without first consulting Parliament.

Mr. SODEN, while admitting the difficulty of the situation, thought that the Board had shown some weakness in their negotiations. His own opinion about the action of the Government was that it was an act of spoliation. £22,300 was not 1s. 4d. in the pound of their capital of £338,000. He would like to known what was the bargain that the Government were making with the French authorities. He was inclined to think that it was an improvident one. He twitted the Chancellor of the Exchequer for following a course in this transaction diametrically opposed to the course he advocated under similar conditions in the year 1868. He thought that the whole question ought to be submitted to the arbitrament of Parliament and the nation before they accepted the miserable proposal of the Government. He concluded by proposing as an amendment,

"*That the meeting be adjourned until Thursday, to give the proprietors an opportunity of further considering the matter.*"

Mr. LEWIS seconded the amendment.

Mr. KING denounced the action of the Government as a piece of abominable shabbiness, considering what the Company had done as the pioneers of submarine telegraphic enterprise. They had a right to expect at least he would not say generous treatment but decent liberality.

The CHAIRMAN said that their rights expired on the 12th of January of this year, and if they had no landing rights for their cables they could not carry on telegraphic communication. By arrangement they had secured one thing for the shareholders—they had secured an extension of the concession up to the 31st of the present month. But the Government had informed him that they did not mean to extend it any longer. The Government had undertaken to purchase their premises, to take over their steamships, stores, &c., at an arbitration price, and if they refused the offer for the cables they must see that they would be imperilling the rest of the arrangement. In his opinion that arrangement with regard to the rest of the property was a fair and reasonable one. They had had for several years a rate of interest which had been very high, and it had recouped them for their big outlay, which was the answer that the Government had given him. If he were, in his private capacity as a Member of Parliament, to bring this question before the House of Commons, the answer would be that he was looking after not the interests of the country but the pockets of the shareholders, and he did not think it desirable to identify his position as a member of that assembly with that of the Chairmanship of the Company. Why they did not put in the circular calling the meeting the amount which the Government offered them was simply because he had hopes that there might be an improvement on the present offer to announce to the meeting, in which unfortunately up to that hour he had been disappointed. He concluded by repeating his belief in the urgency of accepting the resolution he proposed.

The amendment was then put to the meeting, and declared lost.

The original resolution was afterwards put and declared carried by a large majority.

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A series of resolutions were afterwards passed, authorising the dissolution and voluntary winding-up of the Company, and appointing as liquidator Sir Julian Goldsmid, the Hon. Mr. Brand, and Mr. Clare (the Secretary).

A vote of thanks to the Chairman terminated the proceedings.

The Telephone Company of Ireland (Limited).

Report of Directors, to be presented at the tenth ordinary general meeting of the proprietors, to be held at the offices of the Company, Commercial-buildings, Dame-street, Dublin, on Saturday, the 6th April, at twelve o'clock.

The total number of wires (exchange and private, under rental upon 31st December, 1888, was 970. The Municipality of Cork having given permission to erect the requisite poles in the public thoroughfares, a telephone centre has been established in that city. As the exchange was only opened on January 1 last, the subscribers to the Cork centre are not included in the number of the Company's subscribers stated in the previous paragraph as being under rental on December 31, 1888. It will be satisfactory to the shareholders to be informed that the subscribers who had signed contracts before December 31, 1888, for connection with the Company's exchange, exceeded in number those to the local Post Office Exchange, notwithstanding that the latter has been open for more than three years. A large accession to the number of the Company's subscribers in Cork is confidently anticipated during the current year. A trunk line, giving communication between Cork and Queenstown, has also been erected, and will shortly be opened. Other trunk lines to the outlying districts of the city of Cork are in contemplation, some are in course of erection, and it is expected that the Cork system will shortly become one of considerable importance.

Encouraged by the success of the establishment of the exchange in Cork, the Directors are now taking the requisite steps to extend the Company's operations to Limerick. Permission for the erection of the poles in the thoroughfares has been given, and this work is now in hand. It is also proposed to extend the Company's system in other directions so soon as the necessary permission and way-leaves can be obtained.

Owing to the additional labour cast upon the Board by the extension of the Company's operations, it is proposed to fix the Directors' fees from 1st January, 1889, at £300 per annum, and the fixed salary of the managing director at £250 per annum.

The amount standing to the credit of the net revenue account, including the balance of £366. 1s. 5d. brought from last account, amounts to £4,643. 17s. 8d., against £4,314. 3s. 6d. for the year 1887. Out of this sum there has been paid an interim dividend upon the preference shares for the half-year ended June 30, 1888 (£942. 15s. 9d. paid in July last), also the interim dividend upon the ordinary shares (£875 paid in August), leaving an available balance of £2,826. 1s. 11d., as shown in the balance-sheet, since reduced by payment (on January 14) of the dividend upon the Preference shares for the second half of the year to £1,837. 5s. 9d., which the Directors propose to allocate as follows:—For the payment of a dividend on the Ordinary shares for the second half of the year at the rate of 1¼ per cent. per annum (absorbing £1,093. 15s.), equivalent to £1. 2s. 6d. per cent. for the entire year, against 1 per cent. for the year 1887, and ¾ per cent. for the year 1886, and to place to the credit of the reserve fund £417. 13s. 2d. (being 10 per cent. upon the net profits of the year), carrying forward the balance of £325. 17s. 7d. to the credit of the current year, as against £366. 1s. 5d. brought on from 1886.

In conformity with the Articles of Association, Mr. Arthur Dudgeon and Mr. Robert Worthington retire at this meeting, but are eligible for re-election. The auditor, Mr. John M. Kean, also retires at this meeting, but is eligible for re-election.

NEW COMPANIES REGISTERED.

LAING, WHARTON AND DOWN CONSTRUCTION SYNDICATE (LIMITED). This syndicate was registered on the 18th inst., with a capital of £40,000, in £100 shares, to acquire certain apparatus and articles, undertaking, and installations, belonging to the business of Messrs. Laing, Wharton and Down, of 82A, New Bond-street, in connection with the Thomson-Houston International Electric Company's system of electric arc and series lighting. The subscribers are:—P. G. B. Hechnacott, C.E., Newcastle-on-Tyne; J. T. Merz, Newcastle-on-Tyne, chemical manufacturer; Lieut.-Colonel B. H. Martindale, C.B., Bickley, Kent; J. Tennant, Gateshead, chemical manufacturer; W. Crewdson, 60, Courtfield-gardens; E. Waterhouse, 44, Gresham-street, chartered accountant; H. G. H. Norman, 5, Southwell-gardens, barrister. The vendors are appointed managers, and will be entitled to £500 per annum for office rent and salary, and also to 10 per cent. of the annual net profits, but not exceeding £2,000 in any one year.

THE BATH ELECTRIC LIGHT COMPANY (LIMITED).—Registered by Shaw and Blake, Doctors'-commons, with a capital of £25,000, in £10 shares. Object, to adopt and carry into effect an agreement dated March 8th, 1889, made between C. J. Wharton, F. J. Down and A. F. Davies, of the one part, and J. Chivers on behalf of the company of the other part, being an agreement for a license to use and work the Thomson-Houston system of electric lighting in the city of Bath, and within a radius of five miles. The first subscribers are:—Major-General J. Burn, 17, Lansdown-crescent, Bath; Major-General C. A. Benson, Ormond House, Bath; H. G. Massingham, Claremont, Oldfield-road, Bath; J. Chivers, 2, New Bond-street-buildings, Bath; A. Taylor, 8, New Bond-street, Bath; J. Ricketts, 26, Grosvenor, Bath; W. Jeffery, 2, Northumberland-building, Bath. The number of Directors shall be nine, or such smaller number, but not less than three. The first are Major-General J. Burn, Major-General C. A. Benson, J. Chivers, H. G. Massingham, and A. Taylor. Qualification, not less than 100th part of the subscribed share capital. Remuneration, £50 on every £5,000 or fractional part of £5,000 of share capital or debenture of the company, provided a 5 per cent. dividend is first earned on the paid-up share capital.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 22nd, 1889, amounted to £5,670.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).—The accounts of this company to the 31st December last show, subject to audit, a balance of profit of £134,851 after payment of three interim dividends. The directors propose to distribute on the 15th April proximo the usual dividend of 2s. 6d. per share, making a total dividend of 5 per cent. for the year 1888. It is also proposed to pay a bonus of 3s. per share, or 1½ per cent., making a total distribution of 6½ per cent. for the past year. The balance of £66,101 has been carried to the reserve fund, which now stands at £690,455. The share register of the company will be closed from the 6th to the 13th April, both days inclusive.

GLOBE TELEGRAPH AND TRUST COMPANY.—The directors of this company have declared an interim dividend of 3s. per share for the current quarter, payable on the 18th prox.

REUTER'S TELEGRAM COMPANY (LIMITED).—The twenty-fifth ordinary general meeting of this company will be held on April 17th, for the reception of a report and balance-sheet and the declaration of a dividend, &c.

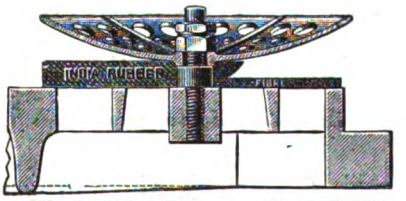
WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 22nd, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited), were £4,130.

Mr. A. B. Blackburn, Assoc.Mem.Inst.C.E., has resigned the position which he has held for some years as resident engineer to the Edison and Swan Company, and has joined the staff of Messrs. Mather and Platt's electrical department, as assistant manager.

Messrs. Mather and Platt, of Salford Iron Works, Manchester, have opened a London office at No. 16, Victoria-street, Westminster, which will be under the charge of Mr. Hardman A. Earle, who has been for some years the assistant manager of their electrical department.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1888.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Price, Wednesday, Mar. 27, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending Mar. 27, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£								
1,770,360	Stock	15/0	Anglo-American	48½ 49½	3 5 8	Jan., Apr., July, Oct.	49½	48½
2,614,820	Stock	30/0	Do. Preferred	82 83	3 18 4	,, ,,	82	81½
2,614,820	Stock	15/0	Do. Deferred	16½ 17	...	February	17	16⅛
130,000	£10	3/0	Brazilian Submarine	13⅝ 13⅞	5 1 0	Mar., June, Oct., Dec.	13⅞	13½
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	101¼	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14 14½	6 4 2	February and August	14⅛	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	2/0	Direct Spanish (£4 paid)	3¼ 4	3 10 0	March & September	4	...
6,000	5	5/0	Do. Preference 10%	8⅞ 9½	5 5 3	April and October	8¾	...
60,710	20	3/6	Direct United States	9½ 10⅛	3 19 0	Jan., Apr., July, Oct.	9⅝	...
380,000	10	2/6	Eastern	12⅞ 13	4 12 4	,, ,,	13⅛	13
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	...	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	107½	107
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	107½	...
250,000	10	2/6	Eastern Extension	12⅞ 13⅛	4 19 1	Jan., Apr., July, Oct.	13⅛	12⅞
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	102½	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust	7½ 7⅝	4 16 8	Jan., Apr., July, Oct.	7⅞	7
178,992	10	3/0	Do. 6 per Cent. Preference	14½ 14⅝	4 2 9	,, ,,	14⅝	14½
150,000	10	5/0	Great Northern	14⅝ 15¼	4 18 4	Jan., July, and April	15⅛	14⅞
17,000	25	12/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	7¼ 7⅜	5 3 2	April and October	7½	7⅜
15,609	10	3/0 1887	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 103	4 18 0	March & September	100⅛	100
30,000	10	6/0	West Coast of America	9¾ 10¼	4 17 7	January and July	9 13/16	9⅝
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅝ 1⅝	...	...	1½	1 7/16
34,563	10	12/0*	Do. 1st Preference 6%	10¾ 11¼	...	April and October	11	10¾
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	...	...
45,181	15	6/0	Western Brazilian	13 13½	5 11 1	March & September	13¼	12 13/16
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	5%	Consolidated Telephone and Maintenance	⅜ ⅝	...	Yearly	...	...
220,000	£1	2½%	Oriental (11s. paid)	⅛ ¼	2 14 11	...	...	...
80,000	5	5/0	United	15 15½	4 16 9	June and December	15 7/16	15⅛
55,000	5	3/0	United River Plate	5⅝ 5⅞	...	January and July	5¼	...
			ELECTRIC LIGHT.					
23,003	5	1/2	Anglo-American Brush (£4 paid)	3¼ 3¾	...	...	3½	3¼
23,692	5	2/0	Do. (fully paid)	4¼ 4½	...	February & August	4½	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	2⅝	...
312,000	½	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42½	42¼
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works xd	17½ 18½	5 8 1	February & August	18¼	17¾

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
Hammond & Co.
J. G. Statter & Co., Limited.

MANVILLE & MADGEN, *Managing Directors.*

3, Prince's Mansions, Victoria Street, Westminster.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 568.—Vol. XXII. FRIDAY, APRIL 5, 1889. Price Fourpence.

NOTES.

The Board of Trade Inquiry into the Metropolitan Electric Lighting scheme (which is being held at the Westminster Town Hall, and not at Richmond-terrace, as at first announced), commenced punctually at half-past ten on Wednesday morning; when it is likely to terminate is a question beyond mortal ken. No less than forty-nine Corporate bodies of one sort and another have secured a *locus standi*; and as they are every one of them entitled not only to bring witnesses of their own, but also, if they see fit, to cross-examine every witness brought by the remaining forty-eight, it is obvious that the proceedings may easily last to least as long as the Parnell Commission. We venture, however, to hope and believe that the fullest rights of cross-examination will not in every case be exercised—in that case we may get through in a few weeks or months.

The proceedings commenced with a brief statement from Major Marindin, R.E. (who is assisted on technical points by Captain Sankey, R.E.), to the effect that the form of the inquiry would approximate as closely as possible to that observed in the case of Private Bills coming before a Parliamentary Committee. The promoters of the various Provisional Orders would, therefore, be entitled to open the proceedings in each case; then the various Local Authorities and others would be heard in opposition; and, finally, the promoters would have the right of reply. It was, moreover, intimated that the Provisional Orders (of which there are thirteen under consideration) would be taken *seriatim*, an arrangement which caused visible grief to the representatives of the Vestries, who naturally wanted the Inspector to deal with each area in turn in respect of all the Orders relating to it.

Mr. Pember, Q.C., then spoke for two hours on behalf of the London Electric Supply Corporation's Order. His company wanted no monopoly. They only asked that the Board should recognise the principle that more than one company might be admitted to the same area. If, however, the Board decided otherwise he would respectfully submit that the area mentioned in his Provisional Order (comprising the entire central district of the metropolis) be granted to his clients. He hoped Major Marindin would visit the works at Deptford before the termination of the inquiry; he might say that they were "large and compact." To supply a district containing only 200,000 inhabitants with the electric light from a station in the centre of the area would necessitate a daily to and fro procession of 204 coal carts. The learned counsel then proceeded to deal *seriatim* with the leading objections which had been raised by the Vestries to various clauses of the Order. All this may be studied in detail on another page.

At the termination of Mr. Pember's address the City Remembrancer (Mr. Goldney) craved leave to state that the City of London, in virtue of its ancient privileges, and charters held itself to be exempt from the operation of the Electric Lighting Act. The question of the lighting of the City would be dealt with in its own way, and, with due respect, without reference to the Board of Trade. He should be glad, however, if the Inspector would give him a convenient opportunity to discuss the matter at greater length. Major Marindin was, however, unable to depart from the position already laid down, that each area would be dealt with in respect of each Order applying to it. The attitude of the City promises to become interesting.

The examination and cross-examination of Lord Crawford occupied the whole of Wednesday afternoon, and was not concluded until half-past two on Thursday. The ground traversed had nearly all been covered in the opening speech of counsel, so that the proceedings became slightly monotonous. The examination of Mr. Ferranti occupied the remainder of yesterday afternoon. Mr. Ferranti described the technical details of the Deptford scheme, with which, however, our readers are already familiar (see especially *Electrician*, October 26, 1888). It is interesting to learn that the experiments on high E.M.F. have now been pushed up to 1,000,000 volts; and that this difference of potential has failed to break down the insulation of the three-quarter inch of brown paper and ozokerite which separates the concentric conductors in the Ferranti main.

We would call special attention to the fact that a Paper on Underground Conduits and Electrical Conductors will be read by Mr. J. B. Verity at the meeting of the Electrical Engineers on Thursday next. In view of the great importance of the subject, we look for a useful and animated discussion. We believe that Mr. Verity will first deal with the necessity of employing some form of duct or conduit for the cables, instancing what has been done in the States, and giving diagrams of three or four of the principal conduits in use there. One of the main points he will raise is that of the necessity or otherwise of lead sheathing. The question as to what is the best form of insulation, both as regards material and the form of the conductors, will also be dealt with.

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At the recent meeting of the Electrical Section of the Chamber of Commerce some informal conversation took place upon a suggestion of the Chairman as to the appointment of an official to assist in the transaction of the business of the Section. Provided only that the right man be found for the post—which need not present much difficulty—not only do we think that such a step would be beneficial, but we shall presently try to show that if the purposes of the organisation are to be at all adequately fulfilled it is imperatively necessary. We recently mentioned that the Electrical Section and its various committees have been holding meetings with not less than ten times the average frequency of the remaining Sections of the Chamber. The amount of additional labour which must have been entailed upon the able and courteous Secretary of the Chamber probably no one but himself can fully appreciate. And although not the slightest expression of any such feeling has been drawn from Mr. Murray, yet as new-comers the members of the Section can scarcely avoid a slightly uneasy feeling at having taken such full advantage of Mr. Murray's readiness to place his services ungrudgingly at their disposal. There is, however, another side of the question which, from a business point of view, is of even greater urgency. It is becoming more and more evident that the interests of the Section can only be properly looked after by some one who has a thorough technical knowledge of the industry, and who possesses the confidence of the members, so as to be able when occasion requires to act upon his own responsibility (in summoning meetings of committee and so on), and someone, moreover, who will be prepared to devote a good deal of time to the business not only in the Chamber itself but also out of doors. In fact, the duties which such an officer might be usefully called upon to perform would be largely supplementary to those at present undertaken by the Secretary, and quite distinct in character.

The need for such an appointment is well illustrated by two incidents which have recently happened, in both of which by no fault of anyone in particular—the very object with which the Section was founded has been entirely frustrated. On the 4th February a committee was appointed to take action on the question of overhead wires. The question was, and indeed is, one of considerable urgency, inasmuch as the Board of Trade were already in consultation with the Local Authorities with a view to framing regulations, and—as announced the week previously in *The Electrician*—they had, moreover, requested the Council of the Institution of Electrical Engineers to appoint a committee to advise with them upon the subject. It was felt, and rightly felt, by the Section that, while the technical aspect of the question was perfectly safe in the hands of the Electrical Engineers, yet it was most desirable that the commercial element should also be represented. It was, therefore, determined that a letter should be addressed to the Board of Trade, requesting that the views of the Section be heard before a final decision was arrived at. This was two months ago, but since that step was taken no meeting of the Special Committee has been held, and absolutely nothing has been done in the affair. Last week, however, it transpired that the Board of Trade had contented themselves with a formal acknowledgment of the letter, though their reply was never brought before the Committee. We do not desire to lay any stress whatever upon the fact of the miscarriage of this reply—a mischance which may easily be accounted for. What we do desire to emphasise is the fact that, in the absence of a responsible and duly qualified official, a matter like this, of the very first importance, may be relegated to a committee which never holds a single meeting! What is equally the business of every individual member of the Committee naturally becomes nobody's business. Doubtless the chief responsibility rests with the Chairman; but, seeing the extent of the duties demanded from him as *ex officio* Chairman of every Committee, and the multiplicity of the other personal engagements which are certain to devolve upon any man qualified for such a position, this is of itself one of the strongest arguments in favour of the proposal which we are supporting.

The other incident to which we have alluded, as illustrating the necessity for the appointment of a salaried official, is of an equally telling character. Nothing can well be more obvious than the fact that when the Board of Trade announced their intention of holding a public inquiry upon the question of electric lighting in the Metropolis, it was the immediate duty of the General Committee of the Section to consider what action should be taken. The emergency which had arisen was one of a kind which the formation of the Section was expressly designed to meet. If it had been found possible to secure united action on this occasion on any particular point or points, however limited, it is certain that a powerful influence would have been exerted upon the ultimate decision of the Board. But notwithstanding the fact that the Secretary was fully alive to the importance of the case, and exerted himself to secure a meeting of the Committee, yet since the Chairman happened to be out of town, and the Vice-Chairmen were for some reason or other equally unavailable, and there was no one else authorised to call the Committee together, nothing was done. It is true that on Thursday last a "Vigilance Committee" was appointed to look after this and other matters, but the time had gone by when any united action could be taken. The result is that each individual company is now fighting for its own hand on all points, and the local authorities will probably reap whatever advantage is to be obtained from their lack of organisation.

No less than five electric launches put in an appearance at the boat race on Saturday. Three of these belonged to the Immisch Company, who also had three of their charging stations moored off Mortlake just above the Ship. The E.P.S. Company's staff were on board the "Lady Cooper," and Mr. Stevens entertained a pleasant party (including a representative of this journal) on board Mr. Reckenzaun's launch "Volta." After the race most of the launches proceeded up the river.

The experiments described in Mr. Preece's interesting Note "On the Disturbances Arising from the Use of Earth for Electric Lighting Purposes" afford conclusive proof that the

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London telephone system would be seriously perturbed if the trunk lines of the London Electric Supply Corporation were laid down in the manner at first proposed. Mr. PREECE apparently made no experiments as to the extent of the interference upon telegraph circuits; but since we understand that the POSTMASTER-GENERAL has formally vetoed the proposal, it is to be presumed that he is satisfied that the telegraph service would also have suffered. It is understood that the London Electric Supply Corporation will evade the difficulty by simply connecting the outer sheath of the concentric conductor to earth at a single point close to the machines, instead of throughout its length. The fall of potential in the 10,000-volt mains under full load between Deptford and Charing-cross will be only about 80 volts, so that the conductor may still be handled with impunity.

IT is a singular fact that with the reduced rates to the Continent, which came into operation on Monday, a reform of quite an opposite kind was silently introduced without provoking, so far as we have noticed, a single comment from the telegraphing public. Last week you could send a message to France for, say, sevenpence-halfpenny, now you cannot do so for less than tenpence, that being the minimum charge for any one message, although the rate per word has been materially lessened. That this fixing of a minimum charge has been effected without opposition speaks well for the administrative capacity of the Government departments; but it also indicates that the public are beginning to recognise the right of cable owners to guard themselves against the too economic habits of their customers. The precedent will not be lost on the great cable companies, who are at present suffering under a word-rate pure and simple, with no service-tax or minimum charge to protect them from absolute loss.

THE persons calling themselves the "British Association of Medical Electricians" recently had the effrontery to attempt to enter into "official" relations with the Institution of Electrical Engineers. We need hardly add that their overtures met with very scant consideration.

As a tribute of respect to the late Mr. PATEY, whose administrative talents were for so many years devoted to the service of the British Postal Telegraphs, we hope shortly to publish a steel-plate engraving of him in *The Electrician* portrait series of electrical notabilities issued by this journal.

Electric Lighting Tenders.—Full details will be found in our advertisement columns of the electric lighting tenders invited by the town of Brussels, and by the directors of the new Exeter Theatre.

Brazilian Submarine Telegraph Company's Debentures.—The drawing for payment of the Five per Cent. Debentures (1884 issue) is announced for the 12th inst. Particulars will be found in our advertising columns.

Worcester.—At a meeting of the Watch Committee, held on Friday last, a letter was read from the Anglo-American Brush Electric Light Corporation offering to send a scheme for lighting the city with the electric light. The letter was referred to a sub-committee.

Western Australian Cable.—The Telegraph Construction and Maintenance Company's s.s. "Seine" completed the laying of the cable from Java to Roebuck Bay, Western Australia, on 27th February, and the thirty days contractor's guarantee having expired, the cable has been taken over by the Eastern Extension, Australasia and China Telegraph Company.

Newcastle.—The Newcastle and District Electric Lighting Company have published the notice legally required of their intention to apply to the Board of Trade, under the Electric Lighting Acts, 1882 and 1888, for a license authorising them to supply electricity for public and private purposes in Newcastle.

The British Electric Light Company (Limited).—According to the scheme of arrangement approved of by the Court, each creditor of this company is entitled to receive one-half of his debt in £10 fully-paid shares bearing preferential interest of 10 per cent. The offices of the Company are at 11, Delahay-street, Westminster, S.W., and the secretary is Mr. J. M. Brett.

Electric Traction in France.—Electricity will be used on the local railway line now in course of construction between Clermont-Ferrand and Royat. The motive power will be derived from a 150 horse-power dynamo at Montferrand. The current, which will have a pressure of 500 volts, will be taken to the cars by an overhead wire, the rails being used as a return. Each train will usually consist of two cars holding fifty persons each.

Colchester.—An extensive system of electric lighting recently established in the steam flour mills of Messrs. Edward Marriage and Son, Colchester, was on Thursday formally inaugurated in the presence of the mayor (Mr. E. J. Sanders) and other gentlemen. The work was carried out by Messrs. Christy, Son and Morris, of Chelmsford. The mill is lighted by 120 16 candle-power incandescent lamps and four arc lamps. The dynamos are by Crompton and Co.

Society of Arts.—The following is the syllabus of Mr. Vernon Boys' lecture on the measurement of radiant heat, at the Society of Arts, on Monday evening next:—Thermo-piles and thermo-elements, Lord Rosse's arrangement, Hutching's instrument, Professor Forbes' instrument, The advantage of reducing the size of the bars, Details of manipulation in the case of very small bars, The construction of galvanometers to be used with thermo-piles and for some other purposes.

Post Office Telegraph Revenue.—The Revenue Returns to the end of the financial year 31st March, 1889, were published on Monday, and show the following results for the Telegraph Service:—

	Quarters Ended.				
	June 30.	Sept. 30.	Dec. 31.	March 31.	Total.
1888 9	£480,000	£565,000	£515,000	£520,000	£2,080,000
1887-8	465,000	540,000	465,000	480,000	1,950,000
Increase during 1888-9	£15,000	£25,000	£50,000	£40,000	£130,000

A Remarkable Span.—The wire belonging to the Western Counties and South Wales Telephone Company, which crosses the entrance to Dartmouth harbour, has the remarkable span of nearly half a mile, viz., 800 yards. On leaving the Dartmouth side the wire is 332 feet above high water mark, it drops to 198 feet near the Kingswear side, and then rises again to 207 feet. The wire is very fine and light, being of No. 17 silicium-bronze, weighing 24lb. to the span. This line has already withstood several strong gales in a most satisfactory manner.

Southampton.—The Special and General Works Committee of the Southampton Town Council recently reported that they had considered a letter from the Southampton Electric Light and Power Company (Limited), for permission to open the pavement in the main streets of the town for the purpose of laying underground mains. They recommended the Council to sanction the principle of electric lighting as proposed, subject to the details and other conditions being hereafter approved by the Committee and the Corporation. The report was adopted after discussion.

The Electrical Omnibus.—The electrical omnibus left the depôt of the Ward Electrical Car Company on Tuesday morning, and ran to Euston Station. Some of the directors and

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the manager of the Liverpool Tramways Company were awaiting it, with Sir George Baden-Powell, M.P., and Mr. Houlding, the chairman of the sanitary committee of the Liverpool Corporation. The omnibus returned by way of Euston-road, Great Portland-street, and Regent-street, to the company's depôt at James-street, Haymarket. It came through the crowded traffic without exciting any alarm on the part of even private carriage horses.

Norwich.—At a meeting of the Norwich Town Council on Friday last, Mr. Green moved, on the recommendation of the Libraries' Committee, that the estimate of Messrs. Laurance, Paris, and Scott to place electric light wires and fittings in the ground and reading-room floors of the Free Library for the sum of £90, and to supply electric light according to the specification at the sum of £80 per annum, be accepted. "No one," said Mr. Green, "who had visited the library since the provisional introduction of the electric light would doubt the advantage." The motion was passed.

Liverpool.—The special committee of the Watch Committee of the Corporation appointed to examine the proposals of the Liverpool Electric Supply Company met last week. A number of representatives of the company attended the meeting, and after a discussion between them and the committee, extending over two hours, a mutual understanding was arrived at by which, while certain concessions are granted to the company, making them in a sense tenants of the Corporation, the interests of the ratepayers are protected. This decision has to be confirmed by the Watch Committee, and then by the City Council.

A New Method of Teaching Chemistry.—There may be more method than madness, says the *Scientific American*, in the longing of the American student for a finishing course at a German university. At a recent discourse on chemistry, Prof. Heinrich Hoffman, of Berlin, illustrated the atomic constitution of organic compounds by the use of the ballet. Each girl was dressed in an individual solid colour and represented an atom, and the grouping and movements of the atoms is said to have been very effective. Chemistry has now become a very popular study with the students, and the attendance at the lectures is very large.

Halifax.—The use of the electric light at Halifax is about to be tried under more satisfactory conditions than has been attempted hitherto. During the past week lamps have been fixed in front of several shops, chiefly by the Schmidt-Douglas Company, of Bradford, and two local firms, Messrs. Blakey, Emmott and Co., and Messrs. Luther, Hanson and Co., are also bestirring themselves. As a result of applications made to the Town Council, a special committee has been appointed to consider the matter, and have recommended the Council to give consent for the carrying of wires, &c., over the public streets. A public company is being formed for supplying electric lighting.

Messrs. Nalder Bros. and Co.'s Catalogue.—The latest catalogue of this well-known firm of instrument makers has been considerably enlarged, and its appearance is much improved by the addition of engravings. Quotations are given for a large variety of standard cells, galvanometers, resistance boxes, condensers and other laboratory apparatus. Messrs. Nalder's new ammeter and voltmeter and their cell testing voltmeter are brought to the notice of the public for the first time: the latter instrument should prove of great use to anyone in charge of secondary batteries. We recommend this neatly got up and comprehensive price list to anyone desirous of purchasing electrical testing and scientific apparatus.

Electricity and Light.—Dr. Moser (*Eder's Jahrbuch für Photographie*) draws attention to the following curious phenomena:—The leaves of an electroscope are caused to diverge by charging with, say, 150 cells. On allowing a ray of direct sunlight to fall on the instrument the divergence is increased, and it returns to its original amount when the light is cut off. A common match (sulphur with phosphorous tip) will glow in the dark when brought close to a charged body such as the cover of an electrophorus. The mercury in a capillary electrometer falls when a ray of sunshine falls on it, just as it does when connected to the zinc of a battery. The effect is distinctly electrical, not thermal, as it vanishes when the upper and lower mercury columns are short-circuited by a wire.

Ballymena.—The electric light seems to be meeting with considerable favour at Ballymena (Antrim), the following mills and private residences being lit by electricity:—Mr. J. Gault's mills and Messrs. Kane Bros.' foundry are lighted by about 100 incandescents, which are run off a dynamo installed about 150 yards away. Messrs. J. H. and G. Bellis' factory and bleach works have an installation of 400 lights. Messrs. Morton and Co.'s large flour mill is lighted entirely by electricity, the dynamo being driven by a large water-wheel; the lights in Mr. N. Morton's private house are also run off the mill dynamo. At Messrs. Raphael and Wolesley's handkerchief factory the dynamo is driven direct off a Beck gas engine. At "Leighinmohr," the residence of Mr. Thomas Anderson, the lights are run off a dynamo 250 yards distance from the house, and driven by a water-wheel. The wires from the dynamo are carried overhead to the house in a single span.

Tramway Companies and Electric Traction.—The following remarks are taken from Mr. W. W. Duncan's monthly report on Tramways and Miscellaneous Securities:—"It rests entirely with the local authorities whether the progress of electricity as a motive power will be rapid or not. In our own metropolis there must be at least 10,000 horses employed upon the various tramways, and surely the removal of those from our streets would of itself be in many ways a very great advantage. At present the companies are all somewhat coquettish in their very natural desire to reap the full benefit for their shareholders, but their eyes will soon be opened to the fact that the pioneers of electricity are not philanthropists, but shrewd business men, who will not move a step until they see clearly that they, as well as the shareholders, are to be the beneficiaries. What is wanted is frank and cordial co-operation, the tramway companies giving the facilities, and using what influence they may possess with the local authorities, and the pioneers taking the risk, which they are quite able and willing to do."

The Post Office and the Telephone.—The Chairman of the United Telephone Company has sent to *The Times* for publication the following letter, which was addressed to the Post Office four years ago:—

"Oxford-court, Cannon-street, March 11, 1885.

"DEAR SIR: The United Telephone Company, being very desirous to extend to the entire public of London the facilities afforded by their telephone exchange, beg for that purpose to make a proposal to the Post Office which they trust will be favourably considered.

"The company is ready to place one or more telephones in every Post Office within the London postal district for the use of the public, who by this means will be enabled to communicate instantly with any of the subscribers to the exchange, now numbering not far from 4,000 of the most important business firms and private persons in London, and daily increasing. My company would be willing to make special terms with the Post Office for such a service, and to make any reasonable arrangement that the Department desires, including the right to the Post Office to take the entire revenue from the fees payable by the public for the use of the telephone.

"Probably, as the Post Office is about to introduce the system of sixpenny telegrams, the same charge of sixpence might—at least in the beginning—be fixed for a telephone talk of a certain number of minutes.

"My company is, however, quite willing that the Post Office should fix the rate, provided it be not too high, the object of my company being, as I have said, to afford to the entire public of the metropolis the utmost possible facilities for the use of the telephone.

"Hoping for an early and favourable reply,

"I am, dear Sir, yours faithfully,

"THOS. BLACKIE, Secretary.

"C. H. B. Patey, Esq., General Post Office, E.C."

Duties on Electrical Apparatus Imported into France.—The following circular has been issued by the Information Department of the London Chamber of Commerce:—"The Board of Trade have kindly communicated the following Memorandum, based on the latest information in the possession of the department, for circulation to the members of the Electrical and Allied Trade Sections, showing the duties levied by France on (1) dynamo-electric machines—(*a*) If weighing less than

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30 kilos. these are admitted free of duty, on the same footing as 'scientific instruments;' (*b*) if weighing 30 kilos. or more they are charged with duty as 'machinery unenumerated,' the duties upon which category are:—Containing 75 per cent. or more of cast iron, per 100 kilos, 6fr.; containing from 50 to 75 per cent., 10fr.; containing less than 50 per cent., 15fr. (2) Electric lamps—Accessories of electric lighting, such as commutators, regulators, lamps, &c., are chargeable as manufactures of metal, according to class, the duty upon such as are of copper or of copper mixed with zinc or tin being at the rate of 20fr. per 100 kilos. Incandescent lamps of blown glass are chargeable as 'Articles of glass not otherwise mentioned;' the import duty under this head 18fr. 50c. per 100 kilos. Accumulators are charged according to the metal of which composed."

The Elieson Sale.—The sale of the plant and patents of the Elieson Electric Company, which takes place within the next fortnight, will not, we venture to think, finally discourage the advocates of battery traction in this country; at any rate, the Elieson system, although it has unfortunately not succeeded in obtaining a permanent foothold on the North Metropolitan Company's line, will, nevertheless, always occupy an important place in the history of electric traction in the United Kingdom. During the nine months that the service on the Manor Park line was well-nigh continuously running, over 400,000 passengers were carried and about 41,000 car-miles were run, and although the system has not been an entire success, it is very far from a failure, an improvement in the batteries being the chief desideratum. The points upon which the proprietors chiefly rely are: the safety arising from the low tension used (180 volts); the adaptability to existing lines; the low cost of first installation, since no alteration of cars or track is required; durability and reliability. The Elieson system, which was described in *The Electrician* (October 21, 1887), involves, as will be remembered, a separate engine car; the motor itself revolves, carrying with it a bevel wheel, which drives at will a right or left-hand bevel wheel on the car axle. We gather from the handsome catalogue issued by Messrs. Wheatley, Kirk, Price and Goulty, that the sale will include the patent rights in Great Britain and Ireland, the United States, Austro-Hungary, Belgium, France, Germany, Italy, Portugal, India, Canada, the Cape, New South Wales, and Queensland, the purchasers of the English patents also obtaining the generating station, plant, and running privileges on the North Metropolitan Tramway Company's lines. The catalogue, we may add, contains some remarkably good illustrations of the Elieson Company's works.

Ship Lighting.—Messrs. W. H. Allen and Co., of York-street Works, Lambeth, have just completed the lighting of a large passenger vessel, built by Messrs. Laird Brothers, Birkenhead, for the Compania Sud Americana de Vapores. The vessel, named the "Imperial," is one of 2,000 tons burthen, propelled by engines of 4,000 horse-power, and is specially built for the trade between Valparaiso and Callao. The boat is fitted with the most modern appliances, and the saloon is lined with maple and satin wood beautifully ornamented with carvings and luxuriously upholstered. The electric light has been provided for every part of the ship, from the mast head to the coal bunkers, and employs over 230 glow lamps of the Edison-Swan type. The signal lights are considerably stronger than can be provided by the best oil lamps, and are so fitted that oil can be substituted, if needful, at a moment's notice. Special brackets are supplied for loading purposes. In the engine room, bunkers, and holds, plugs have been inserted so that the current may be tapped, and a powerful light concentrated in any given spot for temporary purposes. The electroliers for the saloon have been designed to suit the fittings and furniture, and are adapted both for oil and electricity. The lamps exposed to rough usage are enclosed by damp proof bell glasses, and these are protected by strong wire cages. Cockburn's slate switches and fuse boxes have been plentifully used throughout, each state room being separately connected. The conductors branch into six circuits from a six-way slate switch-board, and a second board with the main fuses and fitted with a voltmeter is placed on the return circuit. All the wires are enclosed in wood casings. The "Kapp" dynamo is compound-wound, and capable of feeding the whole of the lamps at the low speed of 280 revolutions per minute. It is driven direct by an Allen twin engine at a steam pressure of 160 pounds. The engine and dynamo are so fitted as to work without vibration, and no sparks are visible at the brushes. The installation has been superintended throughout by Messrs. Allen's electrician, Mr. J. W. Kempster, and gave universal satisfaction on the trial.

The Post Office and the Continental Cables.—A Parliamentary paper bearing the signature of Mr. Raikes, Postmaster-General, issued last Friday, contained the following memorandum explanatory of the relations entered into with Germany, Holland, Belgium, and France as regards the working of the submarine telegraph cables to those countries:—

On the transfer of the telegraphs to the State in 1870, the Post Office became possessed of the cable known as "Reuter's cable" between England and Germany, and two cables between England and Holland previously the property of the Electric and International Telegraph Company. The cables between England and Belgium, and between England and France, remained the property of the Submarine Telegraph Company.

Under an agreement scheduled to the Telegraph Act, 1868, it was arranged that the whole of the cables should be worked and maintained by the Submarine Telegraph Company, and that the land lines in connection with the cables should be maintained by the Post Office. The agreement provided that the earnings from the cables, after certain deductions for maintenance and working, should be divided between the Post Office and the company in the proportions set forth. The arrangements thus entered into were to last until the expiration of the concessions granted by France and Belgium, under which the company had obtained a monopoly of the telegraph business between Great Britain and those two countries. The concessions expired in January, 1889, but as a matter of mutual convenience the arrangements with the company have been extended to the 31st inst.

In 1884 it became necessary entirely to renew one of the cables to Holland, and partially to renew the other. This was work not coming within the definition of maintenance, and under the agreement it had to be undertaken by the Post Office. An expenditure of £45,000 was authorised for the purpose by the Government of the day.

Since 1872 Great Britain has been a party to the International Telegraph Convention, which regulates the international relations between States which possess internal telegraph systems. In the case of all the Continental European States there is a direct interchange of telegraphic correspondence between neighbouring States, and the desire naturally arose that there should be direct transmission of telegrams between England and her nearest neighbours without the intermediary of a private company. Representations to the same effect were received by the Post Office from Chambers of Commerce and other bodies in the United Kingdom. It was obvious that the cessation of the monopoly of the private company might be expected to yield results beneficial not only to the revenue of the countries concerned, but also to the interests of the public. An intermediate stage of transmission would be dispensed with, the rapidity of communication would be improved, and an appreciable reduction in the tariff made possible. Accordingly negotiations were entered into with the German, Dutch, Belgian, and French Governments, and agreements, which will be presented in due course, have been concluded.

With the French and Belgian Governments conventions have been concluded for the purchase, at the joint expense of the respective countries, of the cables of the Submarine Telegraph Company. In the case of Holland a half-share in the two cables connecting that country with Great Britain, which at present belong to the Post Office, will be purchased by the Netherlands Government. In the case of Germany a cable laid between Germany and England by the German Union Telegraph Company has been purchased by the German Government, and the cable between Lowestoft and Norderney, formerly known as "Reuter's cable," will remain the property of this country. A joint interest will thus be created in the cables, and they will be maintained at the joint expense. Each country will provide, maintain, and work its own land lines in connection with the cables, and any additional cables required to meet the increase of traffic are to be laid at the joint expense of the countries concerned. The charges for telegrams, which are at present 3d. per word to Germany and Holland, 2½d. to France, and 2d. to Belgium, will be fixed uniformly at 2d. per word, with a *minimum* of 10d. for a message. Direct wires will be established between Liverpool and Hamburg and between Liverpool and Havre, and various arrangements are being concerted with the Continental telegraph administrations with the object of improving the working of the wires and increasing the speed of transmission of messages.

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THE PHONOPORE.

We now proceed, in accordance with the promise in our last issue, to describe in some detail the system of telegraphy devised by Mr. Langdon-Davies, and which is based upon the employment of the special apparatus which he calls the "Phonopore:"—

The phonopore consists essentially of an induction coil, having one primary and two secondary wires. In circuit with the primary is the battery, transmitting apparatus (Morse key or otherwise), and a vibrating reed. One of the two secondary coils has one end put to earth, while the other is insulated. The other secondary coil has its opposite end insulated, the wire then going to line. The apparatus is, therefore, equivalent to a condenser with self-induction; there is, moreover, no conductive circuit at all between the transmitting instrument at the home end and the receiving instrument at the distant end of the line. The manner in which the phonopore can be made to work side by side with the ordinary telegraphs without in any way interfering with them, or being interfered with by them, will now be shown by describing in detail the actual phonopore line between St. Pancras and Leicester, and two or three of the numerous arrangements of phonoporic apparatus which Mr. Langdon-Davis has carried out in his laboratory. The line upon which the recent demonstration was made is an ordinary telegraph line, 130 miles long, connecting London and Derby (Fig. 1). At the London end of the wire there are two telegraph stations, T_1 T_2, about half a mile apart, and at Derby there is a third telegraph station, T_3, all working ordinary

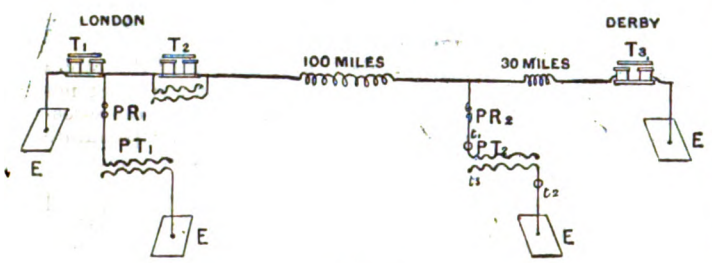

FIG. 1.

T_1 T_2 T_3 = Morse Instruments. P R_1, P R_2 = Phonopore Receivers.
P T_1, P T_2 = Phonopore Transmitters.

Morse instruments through ordinary relays in the ordinary way. At the London end of the line the phonopore is installed in deviation on the line ten yards from the terminal station T_1, the distant phonopore being also in deviation at a point about 30 miles from T_3. One end of the phonopore line is therefore in close proximity to two ordinary telegraph stations less than a mile apart, while the distant post is on a branch line taken from a point in the main line where there is no other instrument. Under these conditions the phonopore works absolutely independently of the ordinary service. In Fig. 2 we see the details of the phonopore station. The transmitting circuit, P T, consists of a Morse key, a battery of 30 cells, a vibrating reed, and the primary wire of the induction coil. The reed is set in vibration on the depression of the key by an electro-magnet (also included in the circuit), and effects a rapid succession of makes and breaks in the primary circuit. In this way the manipulation of the key sends to line through the secondary coil a succession of rapidly alternating current waves in unison with the vibration of the reed. One wire of the secondary goes to earth and the other is connected through the "transformer" to line. This transformer will presently be described in detail. A key is arranged to cut out the transformer when transmitting messages; if, however, the instrument is required to work duplex, the transformer line coils are wound differentially, and this cut-out is not used. So much for the transmitting apparatus. In Fig. 3 we have a more detailed representation of the receiving apparatus, called by Mr. Davies the "transformer," which is in reality a delicate relay designed to enable the "phonoporic" current waves to work an ordinary Morse printer, or sounder. Upon the soft iron core I are wound two coils, L C and A C; the coil L C is placed in the line wire of the secondary coils; the coil A C, called the "augmenter," is in a local circuit in which there is a permanent current from a battery. This local circuit includes, in addition to the battery and augmenter coil, a relay, a galvanometer, and the two vibrators, P V and T V, called respectively the "pendulum" and the "tongue." Over the iron core is placed a steel reed or diaphragm, R R, which, in harmonic telegraphy, is tuned to the rate of the distant transmitter intended to work it. When the transformer is at rest the

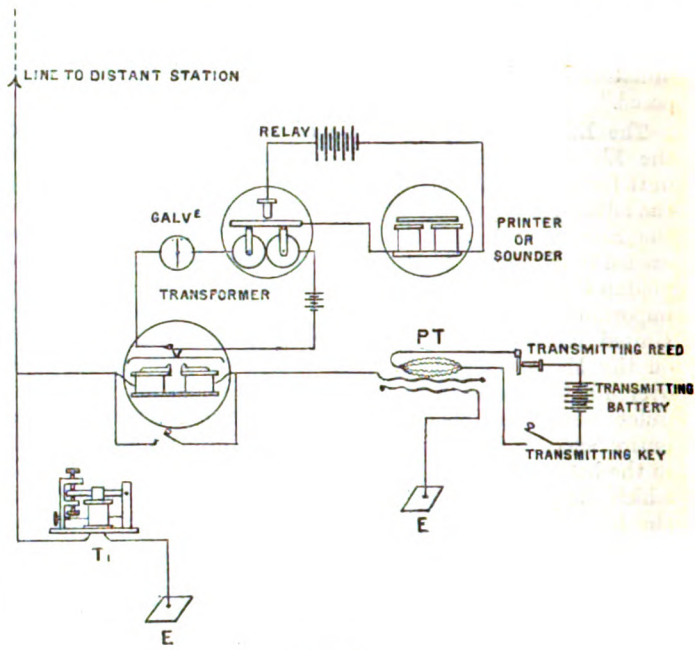

FIG. 2.

vibrator contacts are closed, and the current from the battery magnetises the core and holds the reed in a state of tension. In this condition it is important to notice that the reed is not touching the tongue. The action of the apparatus will now be easily understood. When intermittent currents reach L C from line, they act upon the reed R R. If, however, these vibrations consist of the comparatively slow and irregular impulses usual to ordinary telegraph work, or even of impulses of a regular and rapid character, but not accordant with the pitch of the reed, the vibrations of R R never acquire such an amplitude

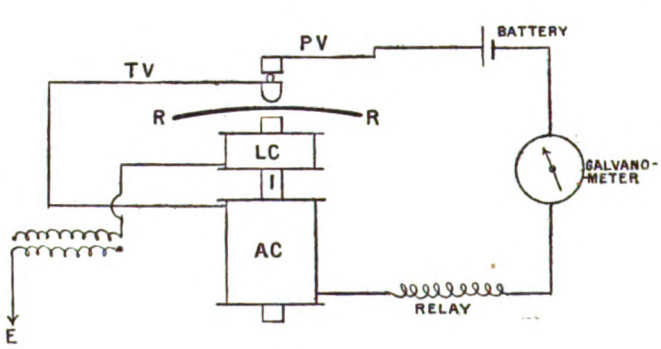

FIG. 3.

as to permit it to touch the tongue, and the contact between P V and T V is not, therefore, disturbed. On the other hand, when impulses are given to R R at a rate corresponding to its natural time of vibration, it speedily acquires such an amplitude as to cause it to touch the tongue and disturb the contact of the vibrators. This disturbance, increasing the resistance of the local circuit, reduces the strength of the current in the augmenter coil A C, and the effect is then to release the reed R R from its condition of tension, and to cause it to strike smartly the tongue T V, knocking away the pendulum D V, and so long as the impulses continue to arrive in L C, the pen-

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dulum is unable to make an efficient contact with the tongue. Now the current which magnetises the core I also holds up the armature of the local relay, so that when the pendulum fails to make good contact with the tongue the armature of the relay falls and the printer, sounder, or other telegraph instrument in the relay circuit, is operated. In some cases the relay may be dispensed with altogether, and the signalling instrument is then put in circuit with the augmenter coil in the position occupied by the relay. The resistance of the London and Leicester line is, we may add, about 4,000 ohms.

Returning for a moment to Fig. 1, we would call attention to a somewhat curious result obtained by Dr. Hopkinson and Prof. Silvanus Thompson. Treating P T_2 as a condenser, Dr. Hopkinson measured its capacity between t_1 and t_2, and made it 0·5 microfarad, the iron core of the coil being in. Measuring its capacity between t_1 and t_3 without the iron core, Prof. Silvanus Thompson arrived at the value 0·083 microfarad.

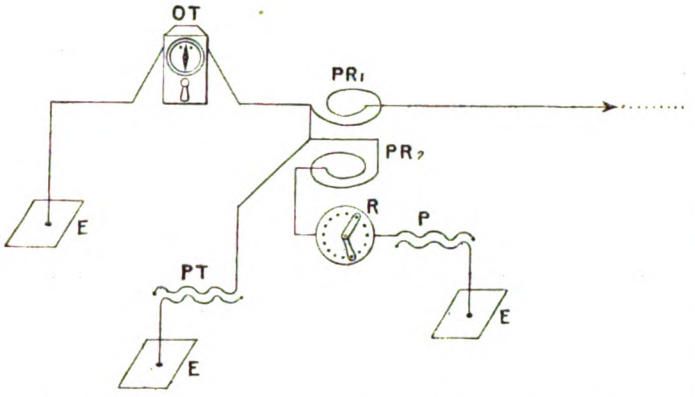

Fig. 4.—Duplex Phonopore Telegraph with Ordinary Needle Telegraph.

O T, ordinary telegraph ; P R_1 P R_2, differential coils of the phonopore receiver ; P T, phonopore transmitter ; R, Rheostat ; P, simple phonopore.

The extreme brevity of the duration of a "phonoporic impulse" suggested a doubt whether duplex receivers could be constructed so as to be practically useful. Experiment has, however, proved that there is no difficulty in working duplex receivers with ordinary differential coils, as shown in Fig. 4.

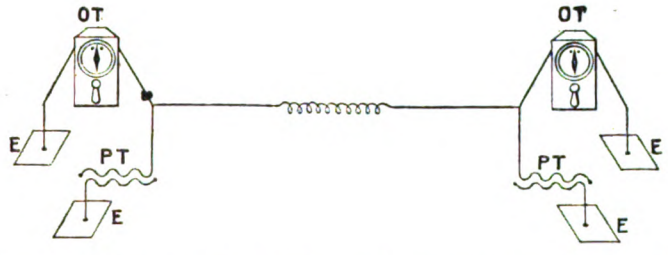

Fig. 5.—Diplex and Duplex Service, consisting of a Simplex Ordinary Telegraph and a Simplex Phonopore Telegraph.

At the recent demonstration, although it was not necessary to do so, one of the strands, P R_1, of the differential coil was placed in the line itself, the other, P R_2, in a balance line to earth, but not direct, a phonopore, P, being interposed between the rheostat and earth. It is one of the many problems suggested by this apparatus that, inasmuch as the resistance of P is infinite, there should be no necessity to add any further resistance in R. The fact, however, remains that unless this resistance is so interposed a balance cannot be obtained. But, at the same time, this system of duplexing with the phonopore has an advantage over the ordinary system, since an exact balance is not required. At the demonstration at which we were present the resistance of the line was altered from 4,000 ohms to 14,000 ohms without disturbing the balance. The balance, however, broke down when the resistance was raised to 23,000 ohms. At the same time, although the ordinary telegraph needle instruments could not be worked with their batteries of 20 cells each, the phonopores, with their batteries of 15 cells each, worked precisely as before. Another system of duplexing a line is indicated in Fig. 5, where we have an ordinary telegraph line and instruments. If, now, a pair of simplex phonopores is installed upon it, two services can at once be worked upon the single wire. The services being absolutely independent of each other, the line might, therefore, be worked either duplex or diplex, as required. In Fig. 6 yet another method of duplexing is shown. In this case there is no balance line at all to regulate, but the duplexing of the instrument depends upon the tuning of the transmitting reeds in the transmitters, and the vibrators in the receivers. P T_1 at A is a transmitter having a transmitting reed whose rate is the same as that of the receiver P R_2 at B. P T_2 at B is a transmitter, the rate of whose transmitting reed is the same as the rate of the receiver P R_1 at A. The rates of these transmitting reeds are so calculated that they not only agree with those of their respective receivers, but so that they do not interfere with their home receiver. Thus, when the transmitter at A is worked, although its impulses pass directly through the receiver at A,

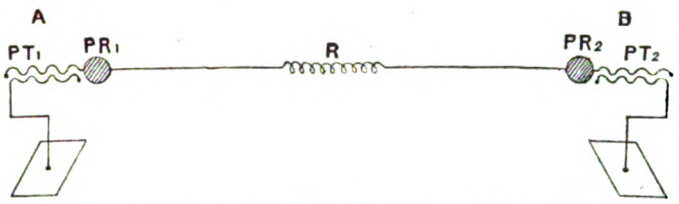

Fig. 6.—Phonoporic Line, for Harmonic Duplex Working.

they do not affect it, but they work the receiver at B, and *vice versâ*. The line shown in Fig. 6 is an ordinary "phonopore" line, terminating at both ends "in air." No ordinary telegraph can, therefore, be worked upon it. The battery power employed consists of 15 cells at each end, and the resistance of the wire is 100,000 ohms. In Fig. 7 we have a perspective view of a simplex phonopore sounder. The transmitting and receiving organs

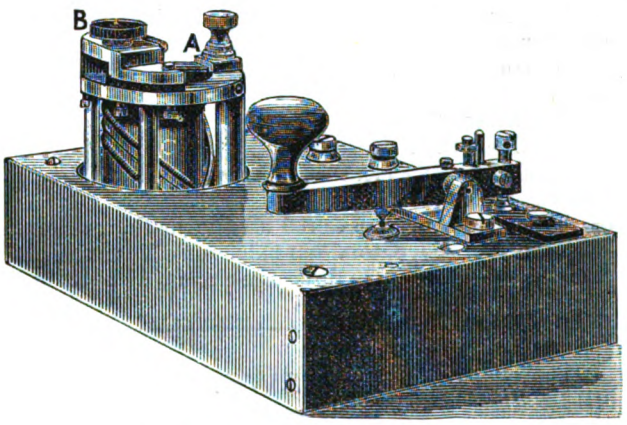

Fig. 7.—Simplex Phonopore Sounder

A = reed ; B = contact screw ; C = ends of secondary coils.

are comprised in a single instrument, and they are intended to work simultaneously with ordinary telegraphs on lines up to 200 miles long. On a simple "phonoporic" line the sounder will work to a much greater distance, the full extent of which has not yet been ascertained. It has worked well through a test line of 100,000 ohms.

We have described above only some half-a-dozen out of nearly 40 combinations and adaptations of which the phonopore is at present capable, but we think we have said enough to make plain the general principle and the chief details of this beautiful instrument. In conclusion we may mention that Mr. Langdon-Davies is at present constructing two Wheatstone automatic instruments adapted to the phonopore. These apparatus were not commenced until experiments had been made with two ordinary Wheatstone automatic instruments transmitting in place of the key of the phonopore transmitter. Although driven at the highest possible speed the phonopore showed itself perfectly competent to deal with the signals.

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SUPPLEMENT TO NOTE ON BURSTING JARS.

BY DR. OLIVER LODGE.

By some mischance the note on page 586 last week was published without some alterations and additions which I had intended and sent in—perhaps too late. It will now be most convenient to annex these as a supplementary note. The only misprint I need correct is where Dr. Ingenhousz is misprinted "Ingerhouse."

When the discharge circuit is a long and thick one, say a No. 0 or even a No. 12 copper wire round a large room, a discharge spark-length of three-quarters of an inch will make a gallon jar spark over its edge a distance of six inches. It is possible that this ease of overflow may prevent it from bursting, one acting as a safety-valve to the other.

I expect jars usually burst when used singly or joined in parallel, seldom when joined in series. The double thickness of glass in the latter case is an obvious consideration, but there is more in it than that. The main reason of the greater safety of jars in series seems to me to be that the electric surgings do not operate on both coatings simultaneously to the same extent as they do with a single jar.

The suggestion at the end of Mr. Boys' letter, about the period of longitudinal vibration of the glass possibly synchronising with the electric oscillation when fracture occurs, is a good one, and future observations should be so recorded that the truth of the hypothesis can be examined. As a convenience I have, therefore, drawn up the following list of things which it is well to record whenever a jar breaks electrically. They are all such as can be easily obtained after the accident.

Data desirable to know in future observations of Broken Jars.

(1) Mode in which jars are connected if more than one.
(2) Total area of effectively coated surface.
(3) Average thickness of effectively coated glass (say by weight).
(4) Quality of the glass (viz., its specific inductive capacity roughly, or at least its specific gravity).
[Or, instead of 2, 3, 4, total capacity of jars, as arranged, before fracture].
(5) Thickness of glass near fracture.
(6) Total length of discharge-circuit.
(7) General arrangement of discharge-circuit (*e.g.*, rough scale plan of same).
(8) Thicknesses of wire or rod used in discharge-circuit.
[Or, instead of 6, 7, 8, total self-induction of discharge-circuit].
(9) Length of air gap in discharge-circuit, with size of knobs used.

REVIEWS.

Treatise on Submarine Telegraphy. By M. E. WÜNSCHENDORFF, Director of Military Telegraphy, France. (Paris: Baudry and Co. 1888.)

(SECOND NOTICE.)

Chapter 9 is occupied with the different methods of laying shore ends, and the theoretical investigations of Messrs. Longridge and Brooks, Werner Siemens and others, on the angles and curves which a cable forms in being laid, as well as the retarding stresses necessary to lay the same in different depths with a certain percentage of slack. No notice is, however, taken of the late Mr. Hockin's formula and tables.

Table II., given at page 272, shows the retarding force according to the formulæ given for different speeds of the ship (1 to 10 knots per hour), for depths from 500 to 3,000 fathoms (not *de* 500 *en* 500 brasses as printed in the text), on the assumption that the slack is 10 per cent. and the weight of the cable a constant. To be of practical use this table requires to be considerably amplified so as to take in different percentages of slack and different weights of cables. A practical example giving the actual dynamometer stresses carried in the laying of a certain cable, with all the data observed, would have been of considerable value. It is of the greatest importance when laying a cable to be able to so regulate the retarding force that the desired percentage of slack is obtained. The usual method employed is that of tightening the brakes until the speed of the cable being paid out is exactly equal to that of the ship, and then easing them until the required percentage is attained. This old method is attributed to Sir Wm. Siemens by M. Wünschendorff. We were not aware that he devised this test. He says that Werner Siemens' plan of paying out a fine pianoforte wire at the same time as the cable has been abandoned, but we believe that Messrs. Siemens still employ this method with success, although we are not aware that any of the other cable companies have yet tried it. For depths up to 1,000 fathoms the slack should be such that the cable can be lifted on the bight for repair without breaking. For greater depths it is hardly worth while to anticipate this special object, if enough slack is just given to let the cable fit the sinuosities of the bottom.

In Chapter 10 M. Wünschendorff gives a very complete and interesting account of the various causes of damage to cables that have been met with. Here we observe that he mentions the Muntz metal ribbon, successfully employed by the Eastern Telegraph Company to protect the gutta-percha core of their cables from the ravages of the teredo, but he has omitted to describe how it is bedded, applied and covered. Lightning protectors receive considerable attention, six different kinds being described. One of the most widely used and successful forms is, however, conspicuous by its absence, viz., that devised by Mr. Saunders, the electrician-in-chief to the Eastern Telegraph Company. The interesting operations of undermining and of grappling for and lifting the cable are next illustrated and described in a manner that makes them perfectly understandable to any one who has never witnessed such work.

Chapter 11 is entirely taken up with descriptions of the most important measuring instruments, and here M. Wünschendorff shows himself thoroughly at home. In his explanation of Sir William Thomson's marine galvanometer, he, however, omits to state that the mirror must be perfectly balanced, otherwise the spot of light will be continually on the move when the instrument is on board ship. We have never met with a description in any text book of how the delicate operation of effecting this necessary balancing is carried out. It is well known, however, that not one mechanician or electrician out of ten can do it so thoroughly that no movement of the mirror is perceptible when the ship is tossing up and down and swinging heavily to and fro. Before proceeding on a cable expedition, all the marine galvanometers should be tried upon an extemporised cradle along with their lamps and scales, and adjusted until no deflection of the spot is observable with a swing or a lift of 25° of the cradle. At pages 322 and 323 no mention is made of the fact that the shunt box resistance coils should be made of wire having the same specific resistance and coefficient for temperature as its galvanometer, and that they should be adjusted so as to read correctly at the same temperature. The scientific reader is, however, admonished not to "fluke" his galvanometer by leaving out the short-circuit plug of the shunt-box when applying or taking off the current! At page 331 it is stated that resistance coils are sometimes made of platinum; surely platinoid is here meant. Platinum-silver is now almost universally used for resistance coils in connection with cable work, German silver and other alloys having been given up long ago. Fig. 285, Thomson and Varley's slides, is copied from "Kemp's Handbook of Electrical Testing," and so are several other cuts from this well-known book, as well as other sources, without acknowledgment or reference note. If the connections were as shown by this figure the battery would be liable to be "run down" or nearly short-circuited when measuring very low resistances. The better plan of connecting up these slides for cable work is shown by the figures at pages 102 and 104 in "Munro and Jamieson's Pocket Book of Electrical Rules and Tables," or as indicated by M. Wünschendorff in Fig. 323, p. 366, where there is a mistake, viz., the reading should be 9,532 on the slides (*"comme l'indique la Fig. 285"*) instead of 9,568 The discrepancy between the two figures 285 and 323 is bound to be very puzzling to anyone not thoroughly acquainted with these slides.

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At pages 336 and 337 we are told to keep condensers short-circuited when not in use. Excellent advice! Not a word, however, about the different rates of electrification of cables and condensers. Neither at pages 337 to 341, nor at p. 389, where Sir Wm. Thomson's method of taking the capacity of long submarine cables is detailed, is there any mention of Lambert's key, without which the connections are very awkward to join up, and the test not easy to make. Gott's method, described at page 387, is much easier to connect up, and no doubt simpler. Some electricians say that it gives equally good results.

All the methods given in Chapter 12 for taking the internal resistance of batteries are old, and are open to objections. They are not to be compared to Munro's method or to the plan of employing a voltmeter to take the difference of potential, *first*, when the battery is in open circuit, and second, when working through a known resistance with an ampere meter in circuit. Neither of these two methods is mentioned. Although almost all the ordinary tests applicable to instruments and cables are given separately, yet we do not find any general or particular information regarding the usual routine of factory testing. No mention is made of the great use of the slide rule or of calculating machines, without which factory tests and calculations would be a very laborious operation. M. Wünschendorff is evidently more at home in the tests as applied during and after the immersion of cables. He gives a full page illustration of the whole of the connections as used on board the s.s. "Dacia" during the laying of the Marseilles-Algiers cable in 1879, as well as the old ship and shore connections, devised and fitted by Willoughby Smith during the laying of the 1866-87 Atlantic cables.

In Chapter 14 all the more important as well as the latest methods of ascertaining the positions of faults in cables have received considerable attention. They have, however, been translated direct from the Papers or writings of each of the respective authors, little or no attempt being made to systematise the index or symbol letters. We do observe, however, a praiseworthy effort in some parts of the book to effect this desirable object, and that M. Wünschendorff has to a considerable extent adopted the first letter of the most important word to indicate the part referred to in a figure or electrical quantity. We see that he invariably uses ω for ohms, and Ω for meghoms, as we do in this country; but he naturally substitutes T for terre where we use E for earth, and P for pile where we use B for battery. The whole of this long chapter, extending from page 403 to page 459, has been culled and extracted, directly or indirectly, from British text-books and journals. Foreign electricians do not seem to have devised any very notable tests for localising faults in cables, if we except the well-known old Blavier test. Although British manufacturers and cable engineers have been very reticent in regard to their part of the work, British electricians have always come well to the front with their methods and devices for testing cables and telegraph lines generally.

Chapter 15 gives an elaborate and very complete investigation of the theory of the transmission of signals in submarine cables, with numerous graphic representations of the retardations of the flow due to electrostatic capacity, &c.

At page 470 the author wisely refrains from saying to whom the credit is due of first introducing condensers between the cable ends and the signalling apparatus. The patent was taken out by Cromwell Varley; but Willoughby Smith claimed the suggestion, as may be remembered from the rather warm discussion some years ago at the Society of Telegraph-Engineers. The fact that the shunting of signalling condensers by high resistances accelerates the rate of signalling is not mentioned, so far as we have been able to observe. No mention is made of Thomson and Jenkin's curb sender, or Count Siccardi's key, with which he laboured so long and tried so many experiments in order to increase the speed of signalling through long cables. In Chapter 16, after describing and illustrating the various forms of apparatus which are in use with short cables, we find complete descriptions of Sir William Thomson's mirror and siphon recorder of the latest electro-magnet pattern, with round mouse mill, &c., but a meagre illustration and description of the new permanent magnet form. He justly gives credit to the well-known Mr. De Sauty for being the first person to successfully duplex a cable—viz., that between Gibraltar and Lisbon of 365 knots in 1873. He was assisted by Messrs. Grigor Taylor and H. W. Sullivan; and the latter still possesses siphon recorder slips showing how perfectly the balance was then obtained and maintained. M. Wünschendorff is, however, evidently ignorant of the great amount of perseverance and ingenuity displayed by Mr. Benjamin Smith in successfully duplexing long cables made up of different conductor sections, or resistances and capacities, a feat which had baffled all other experimenters to overcome. His success in devising and perfecting manual translation is also omitted. Messrs. Muirhead and Taylor's system of artificial line is described, and Dr. Muirhead's experiments and tests in duplexing the Marseilles-Malta, Aden-Bombay, and Direct United States cables are given very fully, as well as the methods of Sir James Anderson and Mr. Harwood, Mr. Stearns and M. D'Ailhaud. Although there are omissions and mistakes to be found here and there throughout this most exhaustive and well-illustrated treatise, yet the perusal of its contents cannot but be interesting and instructive to all those more immediately engaged in connection with the various processes of manufacture, laying, working, and maintenance of submarine telegraphy. The laborious reading and research which the author has exhibited in its compilation, must command the respect of every one who takes the slightest interest in this subject, which, by its far reaching effects, has practically revolutionised the commercial dealings and political intercourse of nations.

a. γ.

The Theory and Practice of Absolute Measurements in Electricity and Magnetism. Vol. I. By A. Gray, M.A., F.R.S.E. (Macmillan and Co., 1888.)

This work is an expansion of the well-known and useful little handbook on "Absolute Electrical Measurements," published in 1884, but the present volume contains more than double the amount of matter in the original work. If the second volume fulfils the promise of the first the work will form a most comprehensive treatise on electrical and magnetic measurement. Chapter 1, comprising the first 135 pages, forms a very good introduction to the mathematical theory of electrostatics. It consists almost entirely of a reproduction with some amplification of the easier parts of the electrostatic portion of Maxwell's treatise: it contains sufficient to enable the student to understand the theory of the construction and use of the electrostatic measuring instruments described in subsequent chapters without referring to Maxwell's treatise. The second chapter contains the elements of the theory of the flow of electricity, with applications to the transmission of signals through submarine cables. The third chapter is devoted to the consideration of electrical units, and their expression in terms of the so-called fundamental units.

The treatment of methods of measurement is begun in Chapter 4, which contains an admirable account of the methods for the accurate measurement of angular deflections and for the observation of oscillations, with the methods of reducing the observations, together with a discussion of torsional phenomena and of the various kinds of suspension used in physical apparatus.

Chapter 5, on Electrometers, consists, as was to be expected, of a description of Sir William Thomson's instruments. We should have liked to find the theory of the guard ring gone into, either in this chapter or in the chapter on electrostatic theory. Maxwell's treatment of this offers great difficulty to the average student; indeed it forms, perhaps, the greatest difficulty of his first volume. This, however, is due in great part to the brevity of Maxwell's exposition, and a little further explanation of the different steps by which the final formula is arrived at would make it much less difficult to follow.

Chapter 6, on the comparison of resistances, is a very valuable one, and contains a good deal of matter, especially with respect to the resistance of electrolytes, which is not easily available except to students who can read German, and who have access either to the original memoirs or to Wiedemann's great treatise. Useful details are given on the care and testing of resistance boxes, and on precautions to be adopted in comparing resistances by the Wheatstone-bridge method. Several methods are given for the calibration of the wire bridge with sliding contacts,

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including the admirable one described by Prof. G. C. Foster in a Paper communicated to the Society of Telegraph Engineers, and afterwards reproduced in German in *Wiedemann's Annalen*. We may take this opportunity of pointing out that this form of bridge should never be used for measurements where accuracy is required without frequent recalibration, as the wire may very easily be injured to such an extent as to give results that are not even approximately correct, without it being possible to detect the injury except by testing electrically.

The seventh and concluding chapter treats of the comparison of the capacities of condensers, and of the measurement of specific inductive capacity. The latter section contains a very good summary of recent work on the subject.

An appendix to this volume contains some tables expressing the relations between cross-section, resistance and weight of hard-drawn pure copper wire, according to the Birmingham wire gauge and the new standard wire gauge respectively.

Numerical formulæ are also given for determining the change in conductivity with temperature of the more important pure metals, and tables of the conductivity and resistance of pure copper at temperatures from 0° to 40°C., and of the specific resistance at 0° in legal ohms of various pure metals and alloys.

We can heartily recommend the volume throughout to the electrical student with a fairly good mathematical equipment, and the practical details of methods of measurement will be of value even to those who are unable to follow the whole of the theory.

Practical, Plane and Solid Geometry. Fifteenth Edition. By John S. Rawle. (London: Simpkin, Marshall and Co.)

The fifteenth edition of this useful little work has been considerably enlarged, and it now contains over 400 problems, covering the whole field of elementary practical geometry. The problems are in most cases accompanied by short notes, pointing out possible variations and extensions of the questions. Several pages are devoted to scales and scale drawing: the number of exercises on this important but often neglected subject might, however, be increased with advantage. The study of this manual should prove a useful preliminary to a course of mechanical or architectural drawing.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

"On the Disturbances Arising from the Use of 'Earth' for Electric Lighting Purposes."*

BY W. H. PREECE, F.R.S., VICE-PRESIDENT.

The magnetic field produced by a current flowing in a straight wire, and returning through the earth, extends to such distances that it is quite impossible to say where or when or how a telephone circuit in that field would be disturbed by any changes in that current. It is quite certain that if a single conductor between Deptford and London were subject to rapid alternations under a potential difference of 10,000 volts—the current returning by way of the earth—every telephone circuit in the metropolis would be disturbed, and probably rendered unworkable. The law determining the distance to which this influence extends was given by me in a Paper read before the British Association at Manchester in 1887. It is given in the following equation :—

$$C_2 = \frac{C_1 l}{d^2 r_2} \times M ;$$

C_1 being the primary currents, C_2 the secondary current, l the length of the primary, d the distance between the wires, r_2 the resistance of the secondary, M a constant dependent on the frequency of the primary currents and the rate at which they rise and fall.

It follows from this formula that currents of rapid frequency on a conductor 10 miles in length, carrying 100 amperes, might be evident at a distance of 19 miles. It becomes, therefore, important to decide to what extent disturbing influences can be eliminated. It is well known that if either the disturbing circuit or that disturbed be constructed of two wires so close to each other and so erected that the mean average distance between the disturber and disturbed is the same, no inductive effects are evident, for the influence on one wire is entirely neutralised by the equal and opposite effect on the other. But if this mean average distance is not equal, or if the equality of the two currents be departed from, then a disturbance will arise which will depend on the difference between the two currents and their relative distances. Hence the most perfectly silent telephone circuit becomes noisy when leaks occur in the insulation, and hence it is that the earth plays such an important part in the efficiency of the system.

It was reported in the technical papers that the London Electric Supply Corporation contemplated laying a concentric conductor between Deptford and London, with the external copper conductor in contact with the earth. As it seemed to the Post Office authorities very doubtful whether such an arrangement would be free from disturbance, experiments were made to test the point. The experiments were made by me in an open space of two or three acres in extent. A concentric cable was constructed so that the outside and enveloping conductor could be insulated or not. The inner conductor was composed of a strand of 19 No. 15 B.W.G. (72 millimetres) copper wires. The outer conductor completely surrounded the inner, and consisted of 24 No. 16 B.W.G. (65 millimetres) copper wires. Each conductor weighed about 1,600lb. per mile, and gave a resistance of ·56 ohm. The outside sheath was of lead The following (Fig. 1) is a full-size section of the cable :—

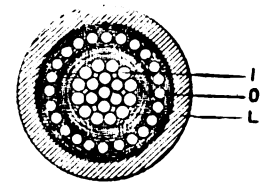

FIG. 1.

The following diagram (Fig. 2) will explain the arrangement of the wires :—

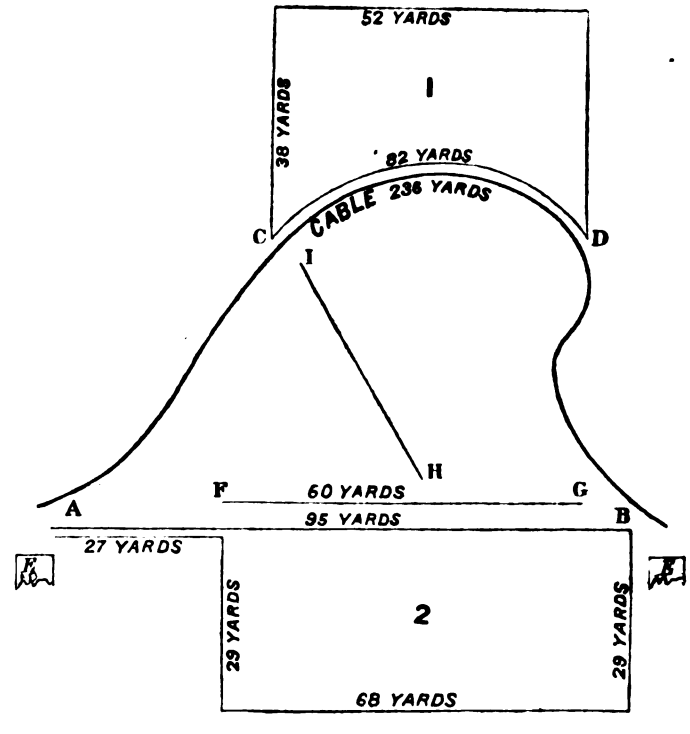

FIG. 2.

Two earth-plates were buried at the points A and B, and between them a No. 7 gutta-percha wire was laid along the ground, telephones being inserted at each end. The electric light cable was laid between the same points by a circuitous route, as shown. At the points C and D two earth-rods were driven in, and another No. 7 gutta-percha wire was laid outside the area enclosed by, and about a foot from, the cable.

Beyond each of the gutta-percha wires extension wires were carried to enable metallic loops to be made up, forming approximate squares (1 and 2 on diagram).

Experiment No. 1.—A Wheatstone transmitter placed at B was connected to the inner conductor (I) of the cable, the lead sheath (L) being used as the return wire. Reversals at top speed (a frequency of 80 per second) were sent through the cable from an E.M.F. of 20 volts, the current strength being about 1·3 amperes.

* Paper read on Thursday, 28th March, 1889.

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Loud disturbance was heard in the telephones at A and B when the transmitter was running.

Experiment No. 2.—Earth-bars were driven in at the points F and G, and connected by a wire and telephone. Currents were picked up by the telephone through this section, their effect being apparently quite as loud as between A and B.

Experiment No. 3.—The points H and I were similarly connected, and with a like result.

Experiment No. 4.—The points C and D were next connected by the wire attached to the earth-bars, a telephone being inserted at D. Disturbances almost as loud as on the circuit A B were heard.

Experiment No. 5.—The wire C D was disconnected with the earth-bars, and a metallic circuit forming an approximate square was made up (1 on diagram). The interference was still heard, but was only about half as loud as when the earth was used at C D.

Experiment No. 6.—The insulated outer *conductor* (O) was substituted in place of the lead sheath as the return wire, and the disturbances in the loop C D ceased entirely.

Experiment No. 7.—The outer conductor (O) and the lead sheath (L) were coupled together, forming jointly a return wire in contact with the earth. The disturbance in the metallic square 1 reappeared, but was reduced in loudness to about half that in the fourth experiment.

Experiment No. 8.—The cable was next laid out straight from A to B, the telephone wire being parallel to it. When the lead sheath was used as the return wire loud disturbance was heard in the telephones at A and B. When the lead sheath and outer conductor were jointly used as the return wire, the noise in the telephones was greatly reduced (to about one-fourth).

Experiment No. 9.—To prove that the result obtained in the last experiment was due to earth conduction, a metallic square (2 in diagram) was formed, and the disturbance in the telephones disappeared.

It follows from these experiments that the disturbance of the potential of the earth at A and B, and the establishment between these two points of a potential difference, causes currents to flow through the earth between A and B which destroy the equality between those in the inner and outer conductor of the concentric cable upon which equilibrium depends. It is therefore quite clear that the use of the external sheathing as part of the conductor in contact with the earth is quite out of the question; whereas if the enveloping conductor be insulated it is quite innocent of disturbance, and would not interfere with neighbouring telephones.

The question has arisen as to whether the currents experimented with (viz., those produced by a Wheatstone transmitter) are of the same character as those produced by an alternating-current machine. The frequency in the two cases may be alike. Taking the frequency at 100, it will follow that each current, whether it be of the Wheatstone transmitter or of the alternating-current machine, will rise from zero to maximum and fall from maximum to zero in ·0025 second. The strength of current generally used in the Wheatstone transmitter is 50 milliamperes, while that of an alternating-current machine may amount to 100 amperes; and since most of the Wheatstone circuits in this country are long circuits, upon which the resistance and the capacity are considerable, it is quite evident that in actual practice the rate at which the current rises and falls is greater in the case of alternating-current machines than in the case of the Wheatstone transmitter. The fact that it is so is sufficiently proved in actual practice. Before the Grosvenor Gallery Company established their metallic loop system, all the telephones around and about Bond-street were disturbed. In order, however, to settle the matter, I have carefully experimented with the currents produced by the alternate-current machines at West Brompton and at Eastbourne, and I find that it is quite impossible to detect any difference between the effects of Wheatstone transmitters and alternating-current dynamos.

These experiments, taken alone, are sufficiently definite to render it decisive that the use of the earth in such instances cannot be allowed; but it may happen that in other systems of distribution where the currents are continuous and steady, such as the systems by which it is proposed to distribute by means of batteries, the earth under exceptional circumstances may be permitted.

The Royal Society.—The following Papers were read yesterday (Thursday) afternoon at the Royal Society:—"The Magnetic Inclination, Force, and Declination in the Caribee Islands, West Indies," by Prof. Thorpe; "Experiments on the Resistance of Electrolytic Cells," by Capt. Sankey.

THE WIRING OF BUILDINGS FOR ELECTRIC LIGHT.*

BY J. D. F. ANDREWS.

The first points for consideration in devising a wire system for electric lighting are, what contingencies will be met with that will affect the system, and what faults will arise in it after its introduction.

Through past experience it has been found that the practical pressure of electricity for electric lighting is (within 50 per cent. either way) about 100 volts, the 100 volts being most generally adopted. The chosen conductor is copper, and the most widely adopted insulation is India-rubber: in many modified forms the insulated conductors are usually protected and held in position by wooden casing. One object of insulation is to protect the wire from the evil effects of moisture, which sets up chemical action in the conductor. The result of the electrolytic and chemical actions on electric light wires is to thin them and make them insufficient for carrying the current, and consequently they become heated; this may even lead to the rupture of the wire causing an "opening circuit." This effect is about the most difficult and dangerous fault to contend with. It is usual to lay the electric light leading wire in a groove in the casing neighbouring and parallel to the return wire. Water often saturates the casing between them, and when the insulation is poor the electricity will pass through the moistened wood and char it, often setting it in flame. Faults such as this, where a great leak is taking place between the wires, are called "partial short circuits," and are equally difficult to avoid, and as dangerous as opening circuits. The study of the insulation of the wires is therefore obviously of great importance. Most of the results in good insulation were obtained by telegraph engineers before the electric light business was started; but in the new business these results were almost entirely ignored. Great insulation was then not considered necessary, and special covering for the wires was devised of a cheap and poor quality, which, it is greatly to be regretted, has continued in use by many contractors to the present day. As previously stated, India-rubber is the base of the insulation of most electric wires—the purer the material the better the insulating properties—but pure India-rubber is easily influenced by air. At first it gets hard, and in course of time changes to a soft, sticky state, when it is useless as an insulation. Pure India-rubber is still the foundation of insulation on the wires, but in the very best qualities it is protected from the atmosphere by an outer coating of what is known as vulcanised India-rubber. Such qualities of insulation consist of, first, one or two lappings of pure India rubber, then a layer of India-rubber mixed with such minerals as soapstone, over which again is laid a coating of rubber, mixed with a large proportion of sulphur. The wire, with its three coatings, is now subjected to a high temperature in a vulcan by means of steam, through which the rubber and sulphur combine, while any surplus is absorbed by the middle coat, which is called the separator. Such is the insulation of the best quality wires. The inferior qualities, and those most generally used, are insulated simply with pure rubber and cotton serving, with ozokerite or other compound tape laid together in many different ways, according to the device of the makers. The compound tape is supposed to protect the pure rubber from the air, but it only plays this function to a small extent. The usual *reliable* life of such wires is from two to three years; and not being reliably waterproof throughout their length at any time, there is always danger of failure through moisture. Vulcanised India-rubber covered wires of the class above described—there are many inferior kinds—is perfectly reliable in water or air for a great number of years.

The next contingency that has to be contended with is mechanical damage. The wires being more or less flexible and the covering soft, they are easily damaged. This difficulty is usually met by casing the wires in wood. Wood casing has the disadvantage of harbouring moisture. Another method of protecting the wires is that of sheathing them with an outer covering of wire, as introduced by the writer some years ago in ship lighting. This method protects the wires much more effectually than casing, and does not harbour moisture. Iron pipes have been used in many cases, and are an excellent protection; but moisture collects in them, and if there should be a fault in the insulation it is sure to find it.

There is another fault besides the opening circuit and partial short circuit not yet touched upon, namely, a dead short circuit, or a direct contact between the opposite conductors. Short circuits usually happen in the fittings when the opposite conductors are necessarily brought nearer each other, and at these points the insulation is generally much thinner and poorer. Short circuits also often happen where the wires cross, frequently by contact with gas or water pipes, which make very complicated faults, because the two wires usually touch the pipes a distance apart, which will be better understood by reference to Fig. 1. Suppose the current to leave the dynamo by the positive wire, pass to the lamps by the branch wires, and

* Paper read before the Philosophical Society of Glasgow, March 20th, 1889

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back by the negative branch wires through the fuse F and the negative main to the machine. Suppose, now, the positive branch becomes connected to a gas-pipe at, say, A : this would not indicate itself in any way, and the installation would of course continue working just the same until the opposite wire got connected to the gas-pipe, say at B. Now the current will become excessive—more than the branch wire can carry without getting dangerously hot—before the main fuse T melts. In the above description it is assumed there is a safety fuse at F, but it will be observed the short circuit has bridged the wire in which it is inserted, and it is consequently useless. To avoid the excessive heating of the wires with such faults as above referred to, it is necessary to have fuses one on each wire, such as at F and S. Under such circumstances, when a short circuit such as described between A and B takes place, the fuse S would immediately blow and prevent danger. Let us again assume there are fuses on only the negative wires, we will see there might have been even a worse fault. Again, supposing a connection at A with the gaspipe, which is, of

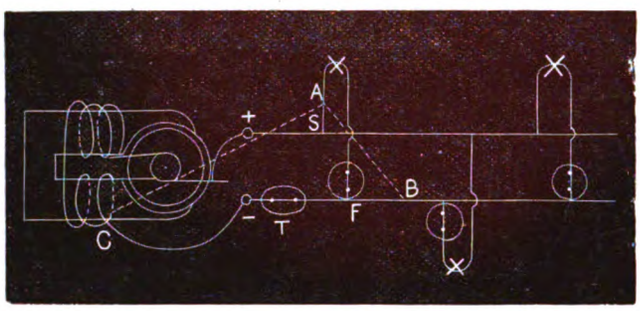

Fig. 1.

course, connected to the earth, we will assume the second connection to take place in the dynamo field-magnets at C. The current will now traverse the positive wire to A, thence to the gaspipe to earth, and back to the dynamo. This route is a short circuit, and one moreover that bridges both branch and main fuses, which we have assumed to be only on the negative wire, as is still the practice of some contractors. The consequence of this short circuit is similar to the one from A to B, but worse, because there are no fuses at all left to protect the system. Of course with another main fuse on the positive wire such a short circuit could not continue.

There is, however, objection to the multiplication of fuses ; they are a danger themselves sometimes, such as in the case of a partial short circuit that does not increase the current sufficiently to melt the fuse, but quite sufficient to heat it to a degree dangerous to any inflammable material in the neighbourhood, and it may continue in this condition some little time before it fuses, especially if it is a large one. Another point of danger from a fuse is that when it melts it throws out sparks of molten metal. Of course it will be said that the evils in fuses can be reduced by proper construction. That is true ; but it is decidedly better to avoid, if possible, numerous points of danger in an installation resting on special construction or the care of an attendant for their prevention. We will consider later how this to a certain extent can be achieved.

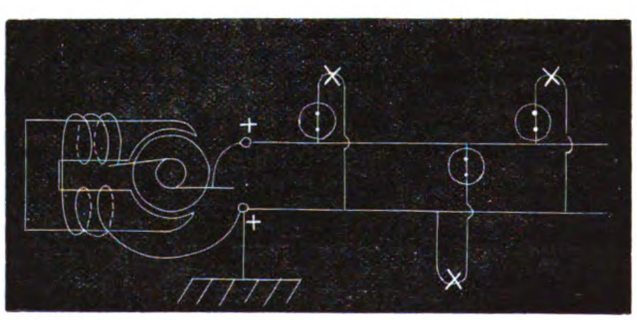

Fig. 2.

In the foregoing we have considered mainly the contingencies or dangers arising from the introduction of electric light into buildings, and we may summarise the main points as being an opening circuit, a partial short circuit, a dead short circuit, and the fuses. We have considered the dead short circuit to be met by the fuse, although a new element of danger is introduced, which, however, is much less in degree. This new element of danger can be reduced to one-half by connecting one of the leading wires, say the positive, to the earth and the gas and water mains, it being only on account of the latter that it is otherwise necessary to provide a fuse on each wire. Fig. 2 will show this more plainly. The current leaves the dynamo by the positive terminal, and meets at once a connection to earth and the gas and water mains, then proceeds by the positive wire to the lights and back to the dynamo. This connection to earth is wilfully effecting the fault we supposed might happen, as in Fig. 1 ; but in making the connection to earth we are careful to do so with that wire which has not got the fuses inserted in it, which is contrary to the action of the fault in Fig. 1. Now, if any of the negative wires come in contact with the gas and water pipes a fuse must instantly blow as if the two conductors themselves had touched. All the electric light fittings would in this case be connected with the positive wire, the negative wire passing down the centre of the

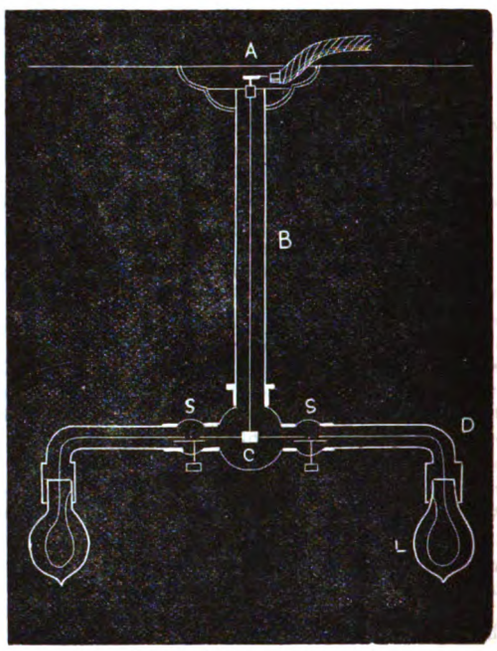

Fig. 3.

tubes. There being in the fittings only a single wire which can be heavily insulated and made stouter, there is an additional safety against short circuits, or fuse melting, besides the very great advantage of being able in a very simple way to wire each part of an electrolier or fitting. Fig. 3 illustrates how this is effected. The current travels from the contact A down the wire B, through the contact C to the switches S S, by the wire D to the lamp L, and back by the brass of the fitting to the ball and socket at the top, and away by the earth wire. The wire inside the tubes is never smaller than No. 14 S.W.G., and the contacts are made with a strong small spiral spring. The contact at the ball and socket joint projects through, and being a box spring it gives and takes with the swing of the fitting, and scrapes on a fixed brass plate in the roof plate. Single or universal joints are quite simple to construct with this system within the same dimensions as for gas, whereas with the two wires passing through the fitting this is impossible. This method of connecting one of the wires to earth is best called the earth system ; it is, however, often called the single-wire

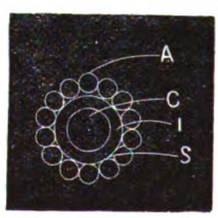

Fig. 4.

system, because in its application to ships the hull of the ship is used as the return wire. In buildings, however, two conductors are required, and as it is important always to be able to distinguish between the negative wire in which the fuses are inserted and the positive wire which is connected to earth and all the electrical fittings, the positive wire is coloured red and the negative wire black. The object of connecting the positive wire to earth is that red coloured wires are usually inferior in insulation quality to black wires, and it is not so important that the return or earth wire should be so highly insulated as the leading wire.

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We now come to the consideration of means for minimising those most dangerous faults opening and partial short circuits. Except the means proposed by the writer in the following paragraph, no attempt has been made to treat these faults except by good workmanship and material. The proposal the writer makes is to universally adopt the sheathed or armoured wire system devised by him some years ago for use in the exposed and damp places on board ships, using the earth-wire system, and now extensively employed for that purpose. The virtue of this system is that all faults, partial short-circuits, and opening circuits, are reduced to dead short circuits. Fig. 4 is an enlarged section of an armoured wire such as is now in use; C is the copper conductor. It is covered with vulcanised India-rubber insulation of the highest class, with a serving of jute and special compound between it and the iron armouring A, which is a great many times larger in cross-section than the copper conductor. Care is taken that it is always more than seven times larger, this being about the difference in electric conductivity of the two metals. It will be understood that the copper wire is the lead and the iron wire the return. It was assumed in devising this system that an opening circuit in the outer conductor was very unlikely to take place, and so it has been found in practice; it is, however, possible that the inner conductor, through undue strain or a flaw, might have an opening circuit in it, and if such were to take place the immediate result would be that the heat generated would destroy the insulation between the two conductors, and at once effect their fusion together and a short circuit. As a matter of fact, however, short circuits in this system have in practice been many fewer, and there have been no opening circuits or partial short circuits. How many of the short circuits were due to such faults is difficult to say; the causes of some were doubtful.

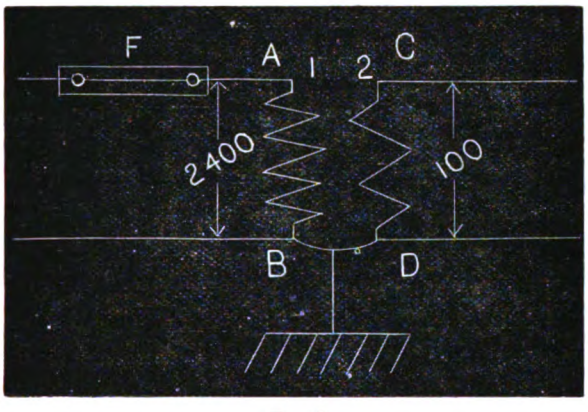

Fig. 5

The writer is not aware of any new danger or contingency being introduced with this system of concentric wiring, although he has heard that some people object to it, and in fact to any system in which an earth connection is introduced; but he has still to learn upon what grounds the objection is based.

In addition to the advantages above referred to, there is another of not the least importance. The electricity being entirely enclosed within the outer conductor, and the electric pressure being only from the centre point to the outer conductor, it is impossible to get a shock through anything more than a very small portion of one's flesh, such as the finger, except by wilful contrivance.

It is advisable before closing this subject to consider how a system of wires supplying a town would be affected by an earth connection of one of the conductors. With any system of supply embodying the series system, I may generally say it is not advisable to employ an earth. I have expressed this point broadly as it involves complex considerations which would take long to make quite clear. But with all systems on the parallel system there are many points favourable to an earth connection, some of which can be gathered from foregoing descriptions. It is more important for us to find out whether there is any objection to its use, and with this in view Fig. 5 is placed before you. It illustrates a transformer with its primary leads and an electric pressure of 2,400 volts at the terminals A and B, where they join the primary circuit 1 of the transformer. F is a fuse in the primary circuit; 2 is the secondary circuit of the transformer, between the terminals C D of which there is represented a pressure of 100 volts; the terminals B and D of the circuits of the transformer are connected to earth, and consequently connected together. The writer is unable to find any danger in thus connecting the 100-volt pressure circuit to the 2,400-volt pressure circuit. Nobody could get a shock to earth, because the pressure between the return wire and earth is reduced to *nil*. The next point is, is there any greater probability of the insulation of the transformer breaking down because the circuits are joined together at one end? This seems to the writer to be answered by a simple calculation; with the earth connection there is no pressure at one end, but all the pressure whatever it is at the other; with no earth connection the pressure is alike at both ends, but at each it is only half the total. The result in both cases is the same. Suppose a connection did get made between the terminals A and C in addition to the earth connection, why the 2,400-volt circuit would be simply short-circuited, and the fuse F would melt. There is, it is true, a very remote possibility of danger in the event of the great improbability of three circumstances happening in succession, viz., first of all, a connection between the terminals A and C as well as the earth, then the fuse F not melting, and thirdly, the circuit of the secondary of the transformer to open between the terminals, and thus put the 2,400-volts pressure on to the lamps direct, which would, as a matter of course, immediately gasp their last.

There is one other circumstance worthy of mention in favour of the earth connection. Should the wire system at any time be struck with lightning there is at once a safe connection to earth instead of having to pass through a highly insulating material as when there is no earth connection. Lightning has already been known to strike overhead electric light wires and discharge itself through the dynamo to earth, to the imminent danger of the machine.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, April 5th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Moulding and Casting Cylinders for Marine Engines." By R. J. DURLEY, B.Sc., Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "True and False Humour in Literature." By the Rev. Canon AINGER, M.A.

SATURDAY, April 6th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

MONDAY, April 8th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture V., 3. "Instruments for the Measurement of Radiant Heat." By C. V. BOYS, F.R.S.

TUESDAY, April 9th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Before and After Darwin." By GEORGE JOHN ROMANES, M.A., F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. "Armour for Ships." By Sir NATHANIEL BARNABY, K.C.B.

SOCIETY OF ARTS.

8 p.m. Applied Art Section. "Architecture in Relation to Landscape." By H. H. STATHAM.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture. "Polarised Light." By Prof. SILVANUS THOMPSON.

WEDNESDAY, April 10th.

CITY AND GUILDS OF LONDON INSTITUTE OLD STUDENTS' ASSOCIATION.

7:45 p.m. Ordinary General Meeting at the Central Institution, Exhibition-road. "Photo-Mechanical Printing Processes." By W. T. BOURNE (Member).

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "The Sanitary Functions of the County Councils." By Sir DOUGLAS GALTON, K.C.B.

THURSDAY, April 11th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Houses and Their Decoration from the Classical to the Mediæval Period." By Prof. J. HENRY MIDDLETON, M.A.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary General Meeting. "Underground Conduits and Electrical Conductors," By JOHN B. VERITY (Member).

FRIDAY, April 12th.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "Iridescent Crystals." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 6 p.m.

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The Electrician.

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SPECIAL NOTICE.

Owing to the increase in the number of pages of "The Electrician," in order to partly cover the increased postage, we have been compelled to revise the rates for Foreign Subscriptions, which are now as follows:—

	3 months.	6 months.	12 months.
For Foreign Parts and Colonies:—	s. d.	s. d.	s. d.
Within Postal Union	6 6	12 6	24 0
Aden, Borneo, Ceylon, China, India, Japan, Java, Labuan, Mozambique, New Caledonia, Persia, Philippine Islands, Siam, Transvaal, and Zanzibar	7 6	14 6	28 0
The rates for the United Kingdom remain as follows:—	5 0	10 0	19 6

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Particulars relating to Advertisements will be promptly forwarded on application to this office.

Trade Advertisements *intended for the current issue must be handed in not later than First Post on Thursday morning.*

Small Prepaid Advertisements *(for Rates see page xi.) are accepted up to 4:30 p.m. on Thursday.*

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 609
The Phonopore. Illustrated ... 614
Supplement to Note on Bursting Jars. By Dr. Oliver Lodge... 616
Reviews 616
The Institution of Electrical Engineers—
"On the Disturbances Arising from the Use of 'Earth' for Electric Lighting Purposes." Illustrated 618
The Wiring of Buildings for Electric Light. By J. D. F. Andrews. Illustrated. 619
Meetings of Scientific Societies. 621
Parliament and the Telegraphs 622
Obituary—
Charles Henry Bennet Patey, C.B., M.Inst.C.E. 623
Economics of Planning and Constructing Electric Light and Power Stations. By Alex. P. Wright. Continued 624
Physical Society—
"The Measurement of High Specific Resistances and the Measurement of the Resistance of Imperfectly Purified Sulphur." Illus.. 625
Relative Amounts of Voltaic Energy of Electrolytes. By G. Gore, LL.D., F.R.S. 626
On the Loss of Voltaic Energy of Electrolytes during Chemical Union. By G. Gore, LL.D., F.R.S 626
Books Received 626
Arc Lamps and their Mechanism. By Prof. Silvanus P. Thompson, D.Sc., M.I.E.E. Illustrated. Concluded 627
The Board of Trade Inquiry on the London Electric Light Provisional Orders 630
American Notes 632
Correspondence—
Mance's Battery Resistance Test.—R. L. Hippisley. Illustrated 634
The Use of Feeders.—Holmes and Vaudrey 634
Patent Record 634
Legal Intelligence—
Chamberlain *v.* The Midland Electric Light Company... 636
Parliamentary Intelligence 636
Companies' Meetings, &c.—
Western Counties and South Wales Telephone Company (Limited) 637
Liverpool Electric Supply Company (Limited) 637
Edmundson's (Limited) 637
The Eastern Extension, Australasia and China Telegraph Company (Limited) 638
The Oriental Telephone Company (Limited) 638
Electrical Power Storage Company (Limited) 639
New Companies Registered 639
City Notes, &c 639
Companies' Share List 640

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GOOD FRIDAY NOTICE.

In Good Friday week "THE ELECTRICIAN" will be published on Thursday morning (April 18th), instead of on Friday (April 19th).

Advertisements for this issue must reach the Publishing Office 1, SALISBURY-COURT, E.C., not later than Wednesday morning.

PARLIAMENT AND THE TELEGRAPHS.

The discussion on the Telegraph vote last week, and especially the statement of the Postmaster-General in regard to it, was of exceptional interest, marking, as they probably did, a turning point in the career of a State undertaking which until now has not been altogether a prosperous one. Mr. Raikes is peculiarly fortunate in being able to announce that the difficulties which have beset the financial welfare of the telegraph service during his predecessors' administration have been gradually overcome during his own; and still more happy in the acquisition of a new branch of its business at a cost far less onerous than that with which the inland telegraphs have been burdened since 1870. The present Postmaster-General, whatever else he may be, is certainly not a common type of the Parliamentary chief of a public department; but that he contrives to get on well with his permanent officials appears to be evidenced by the touching and grateful tribute he paid to the memory of Mr. Patey, the news of whose sudden and lamented death only reached him while the Telegraph votes were under discussion. To the firmness and vigour displayed by Mr.

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RAIKES in defending the interests of his department is probably due this harmonious working with its permanent staff, whose undivided aim and duty are identified with its prosperity. Mr. PATEY lived to see the transfer of the Submarine Telegraph Company's cables to the State virtually completed, and we may take it that he was at one with his Parliamentary chief in the prolonged negotiations which preceded it. The bargain is not what the company expected; but so far as the British Post Office are concerned, they appear to have done their best with the other Governments to represent the Company's case fairly. More than this Mr. RAIKES does not pretend to have done. With his usual outspoken bluntness, he told the House of Commons that he would deal justly by the clerks and officers taken over by the Post Office, "but not more liberally than he was bound to." A similar determination appears to have guided him in dealing with their late employers, who, according to all we hear, have on their part displayed no greater generosity towards their old servants.

It is said that even at the reduced rates which came into force last Monday these Continental cables will repay their cost in less than a twelvemonth. Be that as it may, the proportion of revenue accruing to the British Post Office will be considerable, and probably quite large enough to more than cover the small deficit at which the Telegraph account now stands. With the steady progression under the sixpenny inland rates, and, supposing the European peace to be maintained, the certain growth of Continental traffic, the end of the financial year just commenced will show a substantial balance on the right side. Mr. RAIKES has almost pledged himself to this consummation; and his prediction is not likely to be falsified by any weak or sentimental yielding to public clamour for unremunerative concessions. On those members of Parliament who lectured him—Mr. HENNIKER HEATON was, of course, among the number—about conducting the business and stating the accounts on commercial principles, he retorted that he would be better able to do this if hon. members would refrain from demanding uncommercial privileges for their constituents. To the still more numerous class who have not even yet been cured of their passion for free addresses he held out no hope whatever. It is amazing that at this time of day member after member can get up in his place in Parliament and argue that the withdrawal of free addresses is a hardship which ought to be redressed immediately the telegraphs begin to pay their way. Such is the fact, nevertheless; and but for the firmness of the POSTMASTER-GENERAL, backed, to his credit be it said, by Mr. SHAW LEFEVRE, a fresh crusade against the settlement of 1885 would have been started. Happily, Mr. RAIKES was able to dispose of these gentlemen by pointing to a phenomenon of the word-tariff which has manifested itself in recent years on the land lines as well as on the cables, namely, the gradual diminution in the length of the normal telegram. From 1s. 1d. previous to 1885 the average price paid under the sixpenny rate fell to between 8d. and 9d.; but it has now fallen below 8d.—a fact which shows that the public, trained into habits of brevity, have learnt how to reduce the length of their messages so as to save their pockets. To make them a present of a number of free words under such circumstances would be simply a wanton waste of the Post Office revenue.

Against the abuse of free Railway service messages and the unremunerative rates permitted for Press messages there are more reasonable grounds of complaint. All that can be said on the other side is that these priviliges exist under agreements which it would not be easy to abrogate. As regards the Railways they are supposed to have given over to the Government an equivalent for their right to the free use of its wires at the time of the transfer of the telegraphs to the State nineteen years ago; but the increase of these messages tenfold during that period certainly calls for some explanation. Cheap Press messages were formerly thought to be one of the central objects of a general reduction of the tariff, the country newspapers being in that way placed on an equality with those of the metropolis. Mr. PICKERSGILL, who does not seem to like the news that is nowadays sent to the provinces, is a member for some metropolitan borough; if he represented a provincial constituency he would probably have no fault to find with the Press rates. Any way, it is absurd to say that the Post Office sustains a money loss equal to the price at ordinary rates of the free Railway messages and the cheap Press messages. If charged for at full rates, this portion of the traffic would be immensely cut down, and in the case of Press work would probably yield no more than it does at present. Most of it is done in the night time; and the proper way to deal with it, if it should grow beyond the capabilities of the service when ordinary traffic is suspended, is not to expend more money in expediting this unprofitable business.

A policy of the latter kind seems to have been acted upon for a long time past by the POSTMASTER-GENERAL in his dealings with the Telephone Companies, upon whose present and future business relations with the Post Office he was as emphatic in Parliament as he had been outside of it. The patents will soon expire, says Mr. RAIKES; and then it will be his duty to see that the public re-acquire those rights of which, he is at no pains to conceal, he considers they were deprived by the excessive generosity of his predecessor, Mr. FAWCETT. Meanwhile, he will not enter into bargains or arrangements with the Telephone Companies that might hamper him when the day of readjustment shall arrive. This probably explains why no action has been taken upon the offer Mr. BRAND, in his letter to *The Times* of Saturday, states that his company made to the Postal Authorities in 1885, to fit up a telephone on very liberal terms in every London Post Office. Mr. RAIKES leaves no room for mistaking his intentions with regard to the Telephone Companies, and for that small mercy at least we may perhaps be thankful. It is worthy of remark also that to this part of his statement nobody in Parliament openly took any exception.

OBITUARY.

CHARLES HENRY BENNET PATEY, C.B., M.S.T.E.

The brief announcement which it was our painful duty to make last week of the sudden and untimely death of Mr. Patey, the Secretary for the Postal Telegraphs, had only reached the Institution of Electrical Engineers in the course of its meeting on Thursday evening, March 28, where the intelligence created a profound sensation.

Mr. Patey was in the prime of life, and although not of strong constitution, having suffered from affection of the lungs since his youth, his natural vitality and energy of character, together with his lithe figure, active movements, and almost military bearing, gave the impression that he enjoyed excellent health. A few years ago he had an attack of inflammation of the lungs, so serious that probably he never quite recovered from it; and it was under a similar attack, after an illness of only six days, that he finally succumbed. Mr. Patey, like his eminent predecessor, Mr. Scudamore, had always taken great interest in the affairs of the Society of Telegraph Engineers, of which body he was a member, and for some years occupied a place on its Council. Son of the late Admiral Patey, C.M.G., Charles Henry Bennet Patey began his career as a public servant in the Secretary's department of the Post Office at the age of nineteen; and with the opportunities offered him in the transfer of the Telegraphs

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to the Post Office a few years afterwards he displayed such marked ability that he soon assumed a position of prominence and responsibility. The retirement of Mr. Scudamore virtually placed Mr. Patey at the head of the Telegraph Service, and in 1877 we find him made an Assistant Secretary, from which rank he was promoted to be Third Secretary in 1882. Ever since 1887 Mr. Patey has been the Chief Postal Officer for the Telegraphs; and upon him devolved mainly all the negotiations and business relations with the Telephone Companies and with Parliament in carrying through the scheme of sixpenny telegrams. Latterly the acquisition of the Submarine Telegraph Company's property had taxed his energy and patience to the utmost, and he may be said to have lived just long enough to see the superstructure completed, the foundation of which he had assisted in laying more than twenty years ago. For his services to the State, and perhaps more particularly for those which he rendered at several International Telegraph Congresses, Mr. Patey received in 1886 the distinction of the Companionship of the Bath. He died in his 45th year, and leaves a widow and five sons. His loss is deeply deplored, not only by his family, but by his comrades in the Department over which he presided for so many years.

The funeral took place on Tuesday afternoon at Bromley Cemetery, Kent, in the presence of a large concourse of friends and colleagues of the deceased. Amongst the latter were the Postmaster-General, Sir Arthur Blackwood, Mr. Algernon Turner, Mr. Cardin, Mr. Graves, Mr. Preece, and several representatives of foreign telegraphs. Both Mr. Shaw-Lefevre, ex-Postmaster-General, and Mr. Jackson, Financial Secretary to the Treasury, had intended to be present, but were prevented from doing so by Parliamentary business. The procession was headed by a detachment of Royal Engineers, and by a guard of the Post Office Rifles, a large contingent of telegraph messengers in uniform, and officers of H.M. cable ship "Monarch." Amongst the floral offerings, which were very numerous, was a large wreath received from the French Telegraph Administration.

ECONOMICS OF PLANNING AND CONSTRUCTING ELECTRIC LIGHT AND POWER STATIONS.*

BY ALEX. P. WRIGHT.

(*Continued from page 574.*)

The estimates of cost of property, building, apparatus, and construction are all high, as also the cost of maintenance and running expenses, whilst the rates at present to be considered are low. This is a justifiable course, to provide amply for contingencies in construction and operation, and can be more closely considered when final and detail plans are elaborated.

It will be fair, for the present, to base the rates upon the A estimate, which allowed 4 per cent. for dividend in the first year of operation, more than would be expected in the majority of enterprises, and gives the actual cost for light and power as follows:—

	Per annum.
Full arc lamps, all and every night	$124.32
Divided arc lamps (commercial), average	35.27
Incandescent lamps (including renewals), average	6.94
Motors per horse-power actual	42.25
Motors per horse-power nominal	21.13

The rate for full arc lamps for street lighting may be fairly fixed at $127.75 per annum, or 35 cents per night for all and every night lighting, which is about the present average charge throughout the United States. The rate of $60.00 per annum or $5.00 per month for divided arc lamps could easily be obtained for the average commercial lighting.

The settlement of incandescent rates for various hours of lighting should come later, when more definite plans are decided upon, but an average of $9.00 per annum including renewals, whilst below the general average, would amply repay an investment under the conditions considered here.

The wisdom of including lamp renewals in the schedule rates of an electric light company is questioned by many, but it should be borne in mind that it is very difficult to satisfy the average consumer that any bill for extras above the contract price per lamp or the metered electrical energy supplied to him is not an extortion; and once consumers get such ideas into their heads a feeling will grow against electric light companies as unreasonable and rabid as that universally existing against the much abused gas company and its meter; besides, we are not proposing to enter into business to sell lamps, but light. Incandescent lighting at an average rate of $9.00 per annum for commercial lighting would be equal to gas at $1.00 per thousand cubic feet.

The motor rates being fixed at $45.00 per horse-power, which is considerably lower than that usually charged, the rates may be applied to the three cases, A, B, and C.

A. 60 full arc lamps at $127.75	$7,665.00
170 divided arc lamps at $60.00	10,200.00
4,380 incandescent lamps at $9.00	39,420.00
70 horse-power motors at $45.00	3,150.00
Gross income	$60,435.00
Gross expenditure	48,037.00
Net income	$12,398.00
Dividend 4 per cent. on $230,000.00	9,200.00
Surplus	$3,198.00
B. 120 full arc lamps at $127.75	15,330.00
200 divided arc lamps at $60.00	12,000.00
7,200 incandescent lamps at $9.00	64,800.00
140 horse-power motors at $45.00	6,300.00
Gross income	$98,430.00
Gross expenditure	54,576.00
Net income	$43,854.00
Dividend 12 per cent. on $230,000.00	27,600.00
Surplus	$16,254.00

When the plant as first installed becomes loaded to its full capacity it will become necessary to increase the boiler, engine, and dynamo capacity, and the outside construction, some of the latter necessarily being done more or less at all times. Say that with the surplus and $20,000.00 additional capital, bringing the total capital stock to $250,000.00, the building as provided would be filled to its full capacity as provided for in case C, under which circumstances if the rates were maintained as before the following would be the result:—

C. 300 full arc lamps at $125.75	$37,725.00
350 divided arc lamps at $60.00	21,000.00
8,760 incandescent lamps at $9.00	78,840.00
160 horse-power motors at $45.00	7,200.00
Gross income	$144,765.00
Gross expenditure	86,450.00
Net income	$58,315.00
Dividend 12 per cent. on $250,000.00	30,000.00
Surplus	$28,315.00

Before this point is arrived at the rates might reasonably be reduced to such a basis as to leave sufficient surplus to pay for proper maintenance of the plant in first class order, and leaving something for a reserve fund to be drawn upon in case of unforeseen contingencies, or to make such improvements as the future development of electrical apparatus may warrant.

The rates settled upon, whilst considerably lower than the average at present obtained, are ample under the circumstances described, and in many instances where coal was lower could be reduced with advantage, as low rates will always bring a large business, and would at the same time offer very little temptation to municipalities operating their own lighting service.

Before proceeding to consider the detail of planning and constructing it will be well to carefully determine the lines upon which the work should be carried on, and even at the risk of accusations of repetition it is proposed to reiterate and amplify the remarks made in introducing these articles.

In the first place avoid parsimony, and do not mistake parsimony for economy, and wherever the temptation comes to cut the cloth look back and see what it has been determined liberality will do in the shape of dividend production; many people with a 25-cent piece in their eyes fail to see the 20-dollar gold piece within easy range of their vision. Remember that any departure from the lines laid out, even to a small extent, may upset the whole plan, and that a plan once made it will be better when fairly on the way, as a rule, to carry out. Remember also in making contracts for machinery and material that any of the good and well-known firms will supply good apparatus, and do not pay heed to those who tell you that their competitors' goods are worthless, or guarantee fairy-like results, but having voted or decided upon a certain expenditure for your work do not attempt to make money out of it—that is not the purpose for which you started. Did you not commence with the intention of making money out of the operation of the

* From *Modern Light and Heat* (Boston, U.S.)

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finished plant? Leave the settlement of the details of construction and purchase of materials to your engineer, and when construction is completed, the operation of your plant to your superintendent. Many appear to expect to obtain the highest quality for the lowest rate—they don't really believe so, but try it on. Bear well in mind that if there is any class of work requiring first class material, stability and durability, it is that required in an electric light station operated as it is or will be eventually for twenty-four hours a day, each day in the year. Having chosen your engineer leave him to present plans and specifications for discussion and abide by his judgment, or at all events, if you are not certain on this point, do not attempt amateur electrical engineering on your own part but call into consultation with him some expert engineer.

If now prepared to proceed it will be well to determine the systems of lighting and power to be adopted, particularly the incandescent system. The differences in the principal arc systems are not sufficient at this point to delay the preparation of the plans, which will in most instances suit any system. The determination of the incandescent system as between an alternating and a direct current system is almost necessary at this point.

For the sake of example suppose that an alternating system has been determined upon, being most suitable for the case under consideration. The number and sizes of dynamos to be installed should be determined, and where possible they should be of as large capacity as possible, for economy of space, for efficiency, and for economy in belting, pulleys and shafting. If the number of lamps in circuit does not vary, the largest dynamos are as a rule advisable, as they are proportionately economical to install.

The capacity of 2,000 candle-power lamps to be provided having been determined on the basis of schedule of lighting B, we find to be 120 lamps—60 for immediate use and 60 for future increase. Two 60-light machines or three 40-light machines would answer the purpose, and perhaps it would be wise to determine upon 40-light machines for the present at all events, in which case two 40-light dynamos would be ample for immediate wants with a liberal margin, leaving the third to be installed later. The determination of the sizes of divided arc dynamos requires more careful consideration, and will depend somewhat upon the variation in the number of lamps burning at various hours and periods during the year.

The divided or commercial arc lamps being used to some extent irregularly, the units of dynamo capacity, or at all events some of them, might be smaller. There are 170 lights to be installed immediately, with provision for 200. There will be times when only a small number of lamps may be required after eleven o'clock during the week, in concert rooms or halls, or for special lighting at night, and on Sunday evenings during church hours—say a load varying from 15 to 20 lamps, for which purpose, say, a 20-light machine be adopted. If the 1,200 candle-power curve lines in the figure already used are followed, it will be concluded that 45 or 50-light machines might be used, say, four 45-light dynamos, with which and the 20-light dynamo any desired combination could be arranged to suit the variations of load likely to occur.

Considering the curves again, the incandescent dynamo capacity may be divided as follows, to allow for economical combinations for varying loads, viz., one 500 or 650-light machine, two 1,500-light machines, and 3,000-light machine. The economical subdivision of machine units will always depend in a great measure upon the variations in the incandescent load, and should be as large as possible for obtaining economical results; but some consideration should, of course, be given to subdivision, irrespective of economy, in order that in case of accident only a portion of the lighting is affected, or better still, if possible, as is done in this case, spare machines should be provided. The motor generator we have deemed it wise to choose of the ultimate capacity, namely, 80 horse-power.

(To be continued.)

THE PHYSICAL SOCIETY.

At the meeting of this Society, held on the 23rd ult., a Paper was read by Prof. THRELFALL on

"The Measurement of High Specific Resistances and the Measurement of the Resistance of Imperfectly Purified Sulphur."

The author has been investigating the insulating properties of some of the New South Wales gums. As he finds that none of the gums tested would be of any practical value as insulators, he does not give the actual results attained. The Paper on the "Resistance of Impure Sulphur," however, gives the results of the measurements, being given as an illustration of the method rather than on account of the value of the actual results. The measurements were made by obtaining equal deflections of a resistance galvanometer—first, when a known fraction of the E.M.F. of a Clark's cell was made to act through a megohm in the galvanometer circuit; second, when the E.M.F. of a known number of compared Clark's cells were made to act through a layer of the substance placed between parallel plates of conducting material.

The apparatus employed is shown in the accompanying illustration, Fig. 1. It consists of two thick rectangular brass plates, scraped flat on one surface until one plate would lift the other when placed in contact with it. The upper plate is furnished with a handle something like the handle of a flat iron, loosely attached, so as to cause no distortion when unequally heated, and is pierced by three holes, through which pass micrometer distance screws. In the final arrangement adopted, in order to overcome the difficulty of withdrawing the screws from the gum their centres were bored out and gold-plated copper rods passed through them, and keyed to them until it was required to remove them, the ends of the screws themselves remaining nearly flush with the lower surface of the upper plate. Indices similar to those used in spherometers were fixed to the upper plate, one to each screw. The plates were then platinised by "Roseleur's Process," having been previously prepared by heating to the temperature of boiling water and rubbing the scraped surfaces with a solution of caustic potash, finishing up with fine pumice stone dipped into dilute caustic potash. The author states that he has found this by far the best laboratory method for preparing metallic surfaces for electro-plating. The parallelism of the plates was secured by cementing the plated surfaces with hard paraffin and then screwing brass lugs to each plate, the lugs being brought

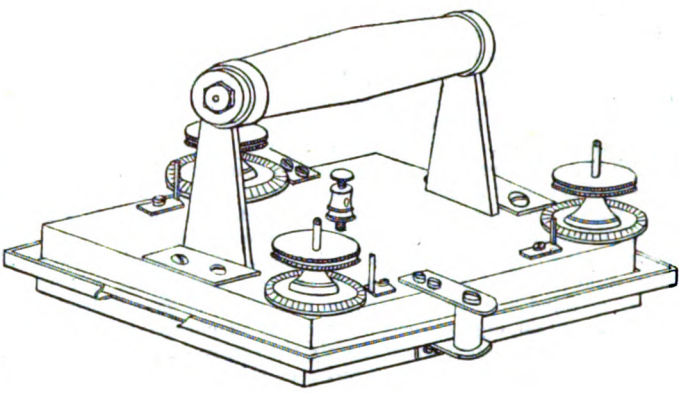

FIG. 1.

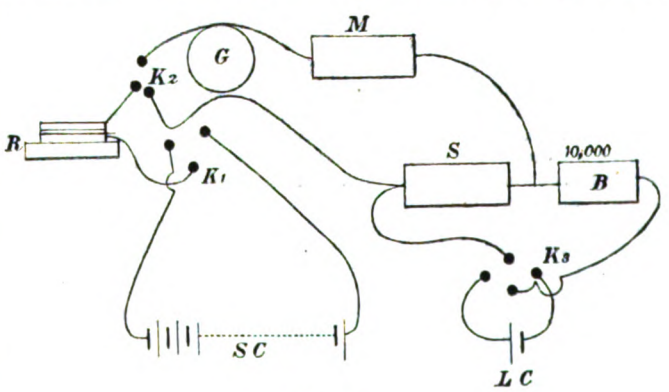

FIG. 2.

as near as possible without danger of contact, after which they were bored to fit slightly conical steadying pins. A rim was then screwed to the lower plate to make it into the form of a tray. In order to prevent deformation from the outer portions of the brass plates being in a different state of strain from the interior, they were cast of about twice the thickness required and the outer surfaces planed off. The positions of the screws when just in contact with the lower plate were permanently marked on them. In order to make a measurement, the plates were adjusted to the desired distance by turning the screws through a known number of turns, and the gum was melted in between them, every precaution being taken to ensure the absence of air bubbles, and the plates were allowed to cool very slowly to obviate any possibility of distortion. The steadying pins were then taken out, and the apparatus was ready for use.

The general arrangement adopted in making the measurements is shown in the diagram (Fig. 2). By means of a key, K_1, a current could be sent in either direction through the resistance R to be measured, and the galvanometer G. S C is a battery consisting of

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a suitable number of small Clark cells. L C is a large Clark cell. The E.M.F.s of these cells were observed during an experiment by means of an auxiliary galvanometer and balance arrangement not shown in the diagram. By means of the key K_2 the resistance arrangement could be put in communication with the last cell, so as to charge up without allowing the current to flow through the galvanometer. After charging, the connections were altered so as to allow the current due to leakage through the substance under test to flow through the galvanometer. The E.M.F. of the small cells was not altered by this amount of leakage, and the fall in that of the large cell was measured in the ordinary manner. Plugs were taken out of the resistance box S until the galvanometer gave the same deflection whether the current were sent through by the battery S C through the substance under test, or by the adjustable fraction of the E.M.F. of the cell L C through a megohm. The sum of the resistances R and S was always 10,000 legal ohms.

Since it was advisable to use thick layers of the substance to be tested in order to diminish the experimental error in measuring the thickness, it was clearly of importance to have a galvanometer of the highest possible sensitiveness, especially since the smaller the E.M.F. the greater was the accuracy with which it could be determined. The experiments made by the author in this direction are of considerable interest and value. His first experiments were made with a galvanometer of 9,000 ohms resistance, made by the Cambridge Scientific Instrument Company, and he found that for currents reaching the value of 10^{-7} amperes, the torsion was of great importance, and by increasing the fibre to 12 inches in length the sensitiveness was increased about fifty-fold. The next step was to obtain a more perfectly astatic system, and to reduce the weight of the mirror. The magnets consisted of discs of steel stamped out of a sheet of the thickness of writing paper subsequently hardened. A piece of aluminium wire of the right length was flattened at the ends, and a pair of discs, selected for their flatness out of a large number, fixed at each end on opposite sides by means of shellac varnish, thus making the wire much more exactly the centre of rotation than in the ordinary arrangement. A piece of the thinnest possible glass, cut out of a sheet previously tested for flatness, was then cemented on to one of the discs by means of slow-drying white paint which the author prefers for this purpose. The two pairs of discs were then magnetised at the same time by means of two small electromagnets which had been constructed with the most elaborate precautions to ensure the utmost possible equality. The two electromagnets were connected in multiple arc, and excited by the same current. The author found that the paint on drying slightly distorted the glass, but it happened to bring it into the form of a vertical cylinder, which gave a good spot of light at a distance of about 3 metres. With a galvanometer of this sensitiveness great care must be taken not to bring the controlling magnets nearer than is absolutely necessary to the suspended system, and to employ only very weak currents. The silk suspension was ultimately replaced by a quartz fibre 85 centimetres in length, owing to the trouble from change of zero due to the silk. A good deal of difficulty was experienced in getting the steel discs forming the magnets exactly into the same plane, but this was finally accomplished so satisfactorily as to bring the period of swing up to 30 seconds. In using this galvanometer the ventilation of the room had to be closed to get rid of air currents, and the galvanometer, cells, resistance boxes, and connecting boxes had to be insulated by resting on paraffin supports. The galvanometer was similar in its general construction to the one illustrated in the preceding Paper. (See *The Electrician*, Vol. XXII., page 590.)

Such an instrument can only be used in a tolerably non-magnetic laboratory and one which is exceptionally free from vibration, and the author found that in spite of the room having a concrete floor resting on twenty feet of broken stone, and the instruments being supported on slate benches, the best results were obtained at night and on Sundays. He considers that there should be no difficulty in constructing an instrument on these lines which should have a sensitiveness of 10^{-13} amperes per scale division, but he thinks that a quartz fibre six feet long should be used. A silk suspension would be out of the question as the zero would be continually on the move. The mirror, he says, should be good enough to be used in a telescope: the base of the instrument should be of gunmetal, and all the framework of metal.

In the discussion which followed the reading of the Paper, Mr. Boys said that he had found in constructing his radio-micrometer that the best method of attaching very thin glass mirrors was to cement them to capillary tubes of the thinnest glass by means of a mere speck of shellac varnish. He did not consider it at all necessary to use a quartz fibre six feet in length, which would, of course, be most inconvenient. By using a sufficiently fine fibre, it need not be more than 15 inches long. He stated that he had obtained quartz fibres $\frac{1}{5000}$ of an inch in diameter, and they would support a weight of two grammes, which was much more than was required of the galvanometer fibre.

RELATIVE AMOUNTS OF VOLTAIC ENERGY OF ELECTROLYTES.*

BY G. GORE, LL.D., F.R.S.

In this research the author has determined by means of the "voltaic balance" the relative amounts of voltaic energy of upwards of 100 aqueous solutions of elementary substances, acids, salts, bases, organic substances, &c.

The method of measuring was as follows:—Take two small glass cups containing known volumes, say half an ounce, of distilled water. Form two voltaic cells of them by means of strips of unamalgamated zinc and platinum. Connect them in series with a sensitive galvanometer of from 100 to 1,000 ohms resistance, so that the currents oppose each other, and the needles are not deflected. This arrangement constitutes the "balance," and is extremely sensitive to change of chemical composition of the liquid in one of the vessels. Make an aqueous solution of known strength of the substance to be measured, and add it in small quantities at a time to the water in one of the cups until the galvanometer needles visibly commence to move, and note the proportion of the substance to the water then contained in that vessel.

As the amount of energy required to move the needles is the same in all cases, the numbers thus obtained with different substances represent the relative amounts of voltaic energy of the substances. And as each substance or mixture gives a different number, it is possible by this method to detect substances, to ascertain their strength, and whether they contain impurities, or have changed in chemical composition. In many cases the method is an extremely sensitive one.

The author has arranged the results in the form of a volta-tension series of aqueous electrolytes, commencing with chlorine, which gives a plus number of +1,282,000,000, and ending with potash, which gives a minus one of −270,985.

ON THE LOSS OF VOLTAIC ENERGY OF ELECTROLYTES DURING CHEMICAL UNION.†

BY G. GORE, LL.D., F.R.S.

In this research the author has shown by suitable examples of measurement of the voltaic energy of different solutions by means of the "voltaic balance" (see *Roy. Soc. Proc.*, Vol. XLIV., pp. 151, 294, 300-308) the successive losses of energy which occur with every additional degree of complexity of a chemical compound. The following are some of the instances given:—

Energy.	*Energy.*	*Energy.*
I ..... =3,310,985	Br... =81,022.500	Cl ..... =1,282,000,000
KI ..... =16,361	KBr..... =66,909	KCl ..... =699,803
KIO^3 ..... =468	$KBrO^3$ ..... =364	$KClO^3$ ..... =239
		„ +KCl ..... =53
		„ „ +$Am^2C^2O^4$=28·4

KCl.	= 699,803
NaCl.	= 207,589
„ + KCl.	= 5,959
K^2SO^4	= 2,274
Na^2SO^4	= 2,020
„ + K^2SO^4	= 112
„ „ + 2 NaCl.KCl.	= 41
„ „ „ + 4 K^2CrO^4	= − 225
„ „ „ „ + 8 K^2CO^3...	= −11,435

In all the cases every addition to the degree of complexity of the definite compounds formed was attended by a large decrease of voltaic energy, and the relative amount of electro-negative energy varied inversely with the degree of molecular complexity of the substance.

BOOKS, &c., RECEIVED.

"Fortschritte der Elektrotechnik." Edited by Dr. Karl Strecker. (Berlin: Julius Springer.)

"Report of the Engineer Commissioner of the District of Columbia on the subject of removing electric wires from the air or surface of the streets and placing the same underground."

"How to Make a Dynamo." A Practical Treatise for Amateurs. By Alfred Crofts. (London: Crosby, Lockwood and Son.)

Proceedings of the Academy of Natural Sciences of Philadelphia. October-December, 1888. (Philadelphia.)

"Economic Value of Electric Light and Power." By A. R. Foote. (Cincinatti: Robert Clarke and Co.)

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* Abstract of Paper read before the Royal Society, January 17, 1889.

† Abstract of Paper read before the Birmingham Philosophical Society.

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ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(Concluded from page 600.)

It would be impossible, in the scope of this Paper, to dwell on the *hydrostatic feeds*, on the various modes of producing *vibrating feeds* and *hammering feeds*, which have been from time to time suggested. The notion of having a *continuous* feed, the rate of which should be varied as required, is an enticing one, but it has never been made a practical success. Neither have the periodic methods of feeding, at which Mr. Brockie made so brave an attempt in 1881; the flavour of which indiscretion still clings about him, in spite of the admirable lamps which he has produced in later years. Mr. Brockie's various forms of arc lamp would indeed well illustrate the whole range of the subject, and the same thing might be said about the numerous successive types of lamp produced by Mr. Crompton. Mr. Brockie has lately produced an excellent little projector lamp for use in the optical lantern, having the negative carbon pressed by spring against abutment screws of steel, whilst the upper carbon is fed forward by a nipping lever controlled by a solenoid. *Abutment* lamps and *projector* lamps form separate classes by themselves, which cannot here be discussed.

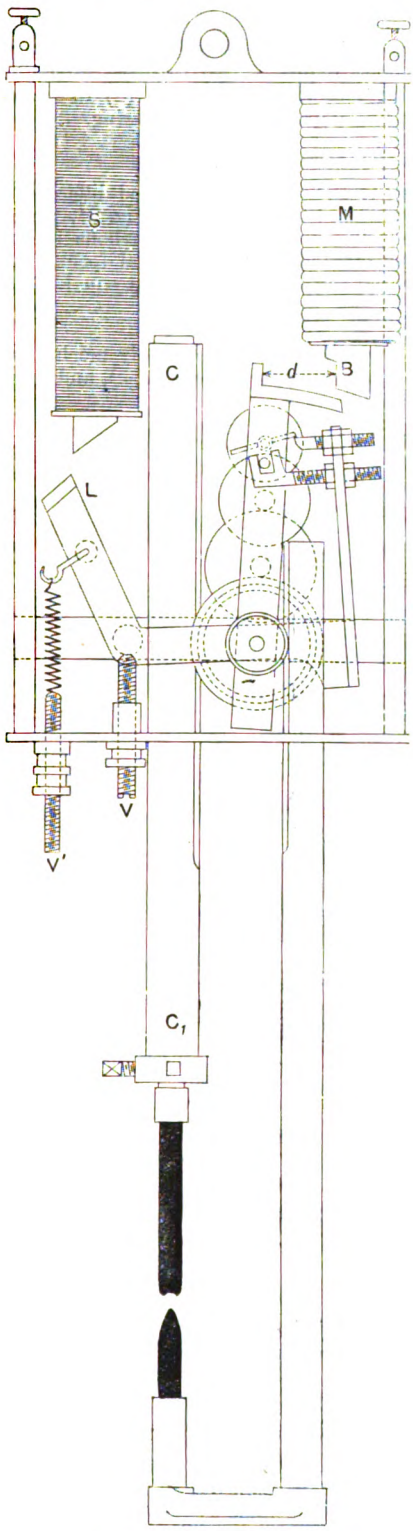

FIG. 23.—De Puydt's Lamp.

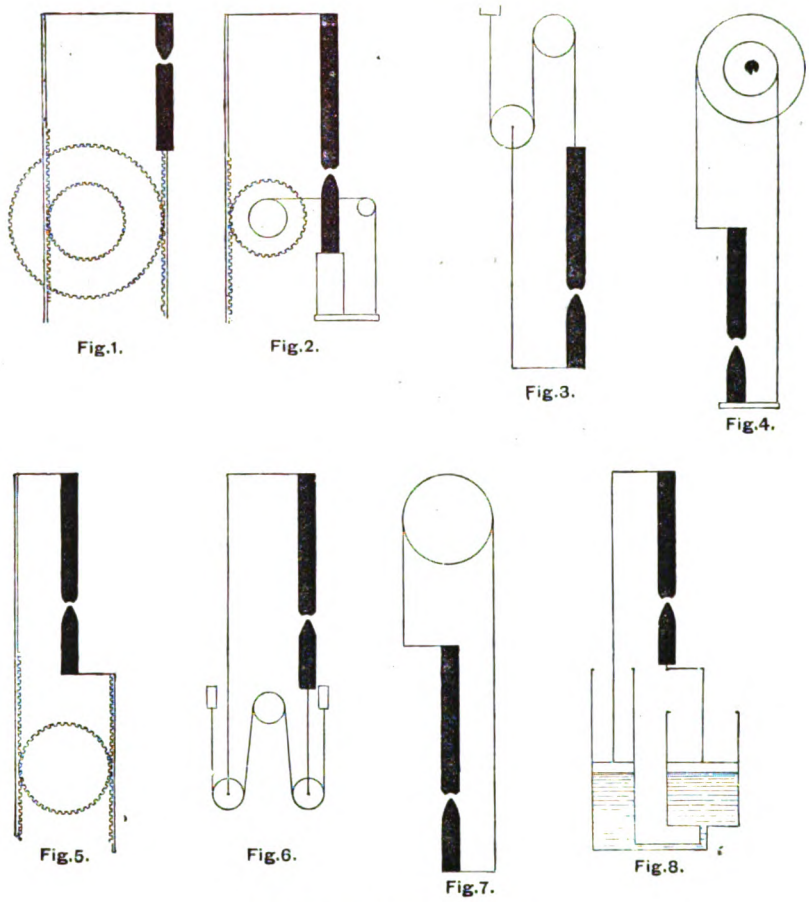

FIG. 24.—Modes of Focussing.

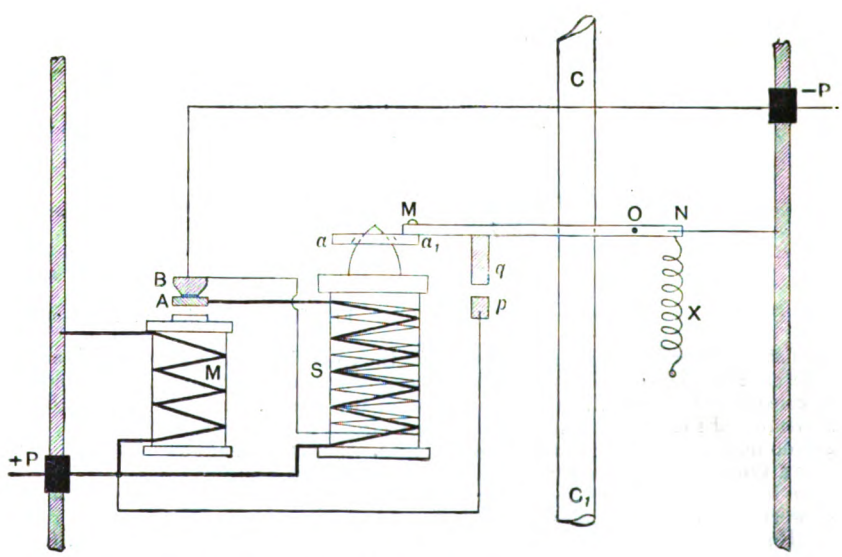

FIG. 25.—Circuits of Thomson-Rice Lamp.

Many of the points alluded to in the preceding descriptions are illustrated by the action of the De Puydt lamp, Fig. 23. This is a rack-train lamp which strikes its arc by lowering the lower carbon and raising the upper simultaneously, and feeds with a fly and detent controlled by a shunt-magnet. The main circuit magnet, M, attracts obliquely its armature, rocking the train of wheels

* Paper read before the Society of Arts on March 6, 1889.

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around the pivot of the first wheel. A lever, L, bent to an elbow which rests on the set screw, V, is also pivoted around the same arbor, and has a vertical arm which carries two attachments; a fork which engages on a pin on the train-frame, and a detent which arrests the fly. The other end of the lever L, is held back by a spring, but can be attracted up by the shunt-magnet S, when the detent is to be released in order to feed.

Product-Regulation.

Before passing away from the feeding mechanism we may return to the question of regulation in general, and in particular to the point that the function of the mechanism of the lamp is to maintain constant one of the two factors of the electric energy, the dynamo being responsible for the other. That part of the electric mechanism which controls the feed is responsible for the steady working of the lamp; and it is this which has to be sensitive to the fall of the current (in constant potential lamps), or to the rise of the potential (in constant current lamps). It is this which must control the feeding mechanism of the lamp. It may be remarked that the striking electromagnet represents the muscle of the lamp, but the feeding electromagnet represents the brains. Now, if the brains of the lamp have to think about and control one factor in the product, why can they not be made to think about and control the product itself? Such a lamp, in which the controlling part is neither an ampere-meter (main circuit) device, nor yet a volt-meter (shunt) device, but a watt-meter device, ought to make the lamp independent of any fluctuations in the supply. Product regulation is clearly in the abstract better than regulation either by the amperes alone or by the volts alone, or by the difference between them; and the mechanism is certainly such as can be constructed. Such a lamp ought to run on any circuit. Let it be remembered that on a constant potential circuit a shunt-magnet can do no more than a spring might do. Neither can a main-circuit magnet in a constant current circuit do more than a spring. A lamp in which both coils are properly combined ought to be capable of working on either kind of circuit. Indeed, there are some existing lamps which will very nearly do so.

Relay Lamps.

It is evident that the brains of the lamp need not necessarily be placed inside the lamp itself; the device of using a sort of *relay*, outside the lamp, to watch the lamp and control its feed, is one that has been frequently suggested (Crompton, Abdank, Gerard, &c.). There is one lamp (Jolin, 2570[83]), in which a shunt relay, itself too weak to move the feed tilting-plate, does the work by opening and closing one of the circuits of a double, differentially-wound, main-circuit electromagnet.

Retarding Mechanisms.

It would be very easy to write a whole chapter on fans, air dash-pots, glycerine dash-pots, and the innumerable devices which have been tried. Two are worthy of mention, namely, Hopkinson's device (153[81]) of altering the rate of feed by raising or lowering mercury in a vessel in which a fan is continuously rotating, and Brockie's suggestion of a liquid brake-wheel containing internal partitions, communicating by small apertures, so that a liquid could flow but slowly from one chamber to another.

Replacement Mechanisms.

These may be classified as follows:—(*a*) In rack-train lamps, a ratchet-wheel on first or second member of train. (*b*) In clutch-lamps with loose clutches, none required. (*c*) In forward-feeding clutch-lamps, some device for loosening the clutch. (*d*) In screw-feed lamps, some device for unclamping the screw gearing.

Focussing Mechanisms.

The various ways of giving to the carbons the desired differential rates of approach are best classified by reference to Fig. 24, which gives four methods of producing a motion of the carbons in the ratio of two to one, and four methods of "commercial focussing," in which the carbons are moved toward one another at equal rates.

Change-over Mechanisms.

These may be classified into those which are purely mechanical (Brush, Thomson-Rice, Bürgin, Crompton-Crabb, &c.), and those which are electrical, the current being switched off from one pair of carbons, and switched on to another (Weston, 1163[82]; Waterhouse, 5185[81]; Trott and Fenton, 6910[87]; Noble, 16376[87], &c.).

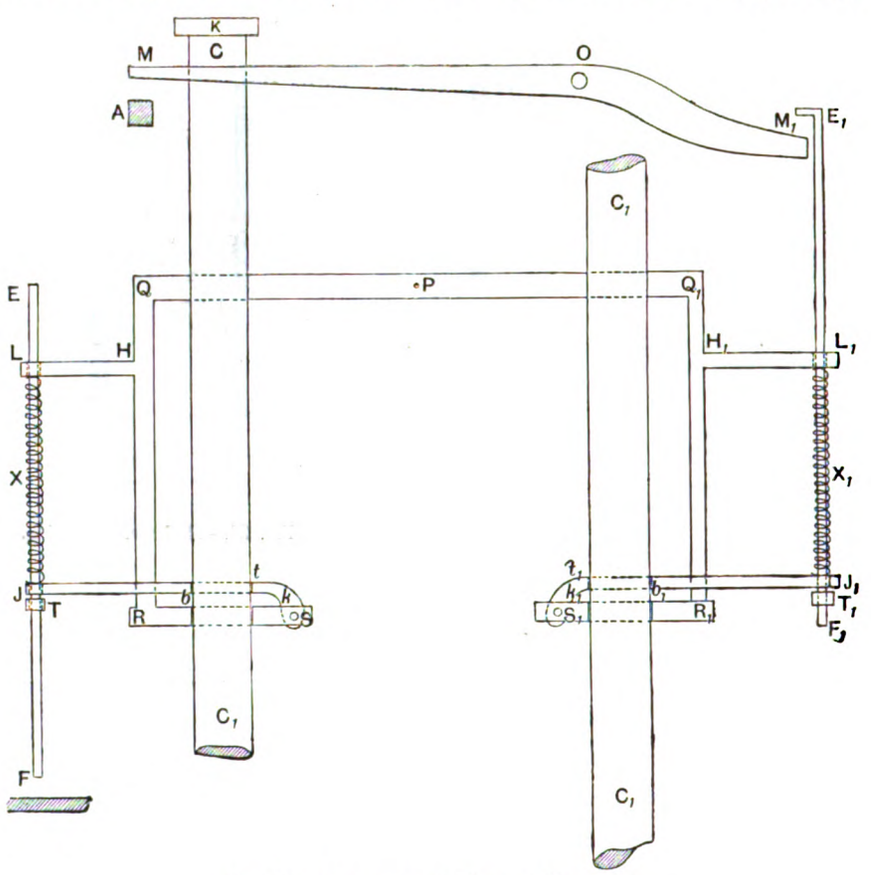

Fig. 26.—Mechanism of Thomson-Rice Lamp.

Cut-out Mechanisms.

"Cut-out" mechanisms may also be purely mechanical, but they are more usually electrical, and, in modern forms, enable the lamp to "cut-in" again on the re-establishment of its proper circuit. Cut-outs which enable a shunt-magnet to strike and feed the arc are described by Lever (8443[84] and 11501[84]), and are used in the Thomson-Rice lamp. The latest devices are those of Lauckert (5707[87]) and Phillips and Harrison (7235[87]). In many lamps the cut-out circuit is merely a shunt electromagnet stiffly set, which, on the failure of the lamp, receives the whole current, and pulls over a cut-out switch. Gerard (4792[81]) describes several such devices as well as a cut-out depending on expansion by heat. In the Pilsen lamp (Fig. 21) the cut-out is in an auxiliary main-circuit. Cut-outs depending on the fusion of a wire or of a washer have

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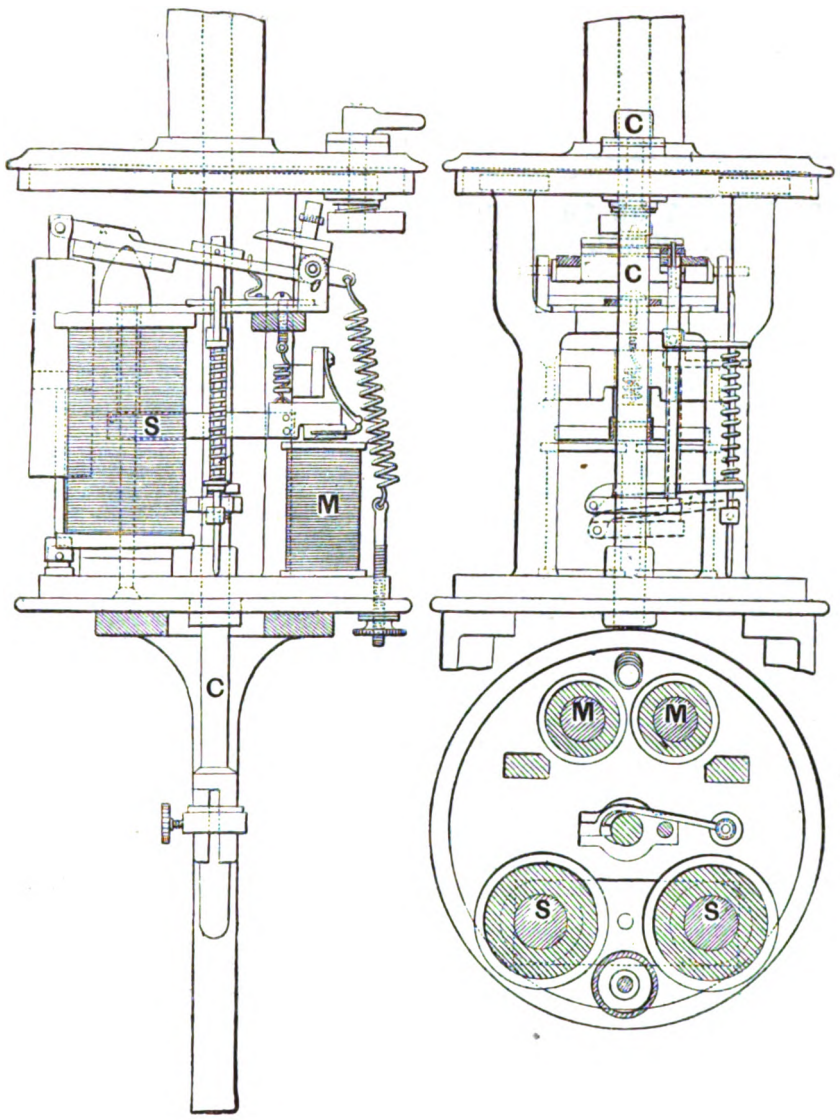
been proposed by Lontin (20947), Basilevsky (50268), and M'Dill (1887).

The action of change-over and cut-out mechanisms is well illustrated by reference to the Thomson-Rice lamp, of which Fig. 25 illustrates the electrical mechanism and Fig. 26 the mechanical mechanism of the lamp. The terminals are marked +P and −P. The carbon rods, C C and C_1 C_1, are held up by their respective clutches, which are identical with those of the Thomson-Houston lamp (Fig. 14) already described. The clutches, when the lamp is not at work, are themselves held up by the spiral springs, X X, which push down the levers, J and J_1, and push up the arms H L and H_1 L_1, so gripping the rods. The principal electromagnet, S, with its conical poles, has a pierced armature, *a a*, mounted on the end of a strong lever, M N (Fig. 25), which is pivoted at O, the first round the coarse wire on S, most of it going through A and B (which are in contact), and on to −P; but a little of it, after traversing the coarse wire coil, turns back along the fine wire coil and goes by this by-pass route to B and −P. As a result, the armature is strongly attracted, and the lever M N descends, causing the carbon rod to drop. This now opens another route for the current. Starting at +P, some of it will flow through M to the frame, thence through the upper and lower carbons and so to −P. This current will attract the armature A, and break the contact between A and B, breaking the coarse wire circuit through S, leaving the fine wire path still available. Consequently S loses most of its power, and the spring × pulls up the lever M N, so striking the arc. The shunt-circuit (fine-wire) through S is still at work, and continues to operate the feeding, increasing as the resistance of the arc lengthens.



General View of Thomson-Rice Lamp.

M. The cut-out (or cut-in) electromagnet which opens the contacts of the coarse-wire winding on the electromagnet S.

S. The principal electromagnet, wound with fine and coarse wire. The armature of this electromagnet is attached to a lever pivotted at O, and held at its other end by a strong spiral spring. This armature in sinking opens the clutch, and in rising closes it on the carbon-rod, which it raises.

short tail, O N, being pulled down by a powerful spring, X. This lever, thus held up above the poles of the electromagnet, is connected to point P (Fig. 26) of the clutch frame, and holds it up. The adjusting nuts of this frame are so set that when P descends the lower end, F, of the pin, E F, strikes on the base plate and opens the clutch for the left carbon rod, so striking the arc of this pair of rods. When the pencils of this side are consumed, the rod, C C, has descended so far that its projecting head, K, strikes the long lever, M M, the other end of which raises the pin, E F, so bringing the other clutch into action. The electric arrangements, Fig. 25, are as follows:—The magnet, S, is wound with a few turns of thick wire, and with many turns of fine wire. The cut-out (or cut-in) magnet, M, is wound with coarse wire only. The upper carbon rod is connected electrically to the frame of the lamp, whilst the lower carbon, insulated from the frame, is joined by a wire (not shown in the figure) to the negative pole. The current entering at +P passes

The present attempt to furnish a classification of the various mechanisms, electrical and mechanical, of the arc lamp, is probably extremely imperfect, but it may at least claim to supersede the old and ludicrous division of lamps into "monophotal" and "polyphotal." In conclusion, it may be pointed out that there exists a curious sort of family likeness between the several members of the three species of lamps most in use. The rack-train lamps, which may be considered as the prevailing continental type, are for the most part, in their design and construction, essentially clockmakers' lamps; they have a horological aspect. The clutch lamps so universal in America have a sort of sewing-machine look, the working parts being only finished where necessary for actual work, all else being left rough merely or painted over. The clutch-wheel lamps favoured by British inventors have, in contrast to these, a look as though they had been designed and constructed by a trained engineer; they are essentially engineers' lamps.

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APPENDIX.—SAMPLE OF FILLING UP OF SCHEDULE.

Schedule of Arc Lamp Mechanism.

NAME OF LAMP.—Thomson-Houston. Single arc.

NATURE OF SUPPLY.—Constant current; amperes 9·8.

RESISTANCES.—*Main circuit coil, 0·09; shunt, 279; cut-out, 0·85 ohms.*

A	*Driving power*.....	Gravity on upper carbon-rod.
B	*Striking*	Main-circuit electromagnet attracts lower end of see-saw, lifts clutch.
b	*ditto adjustment*...	(1.) Special resistance-coil shunting main-circuit coil. (2.) Spring on tail of clutch.
C	*Feeding*	Shunt electromagnet attracts upper end of see-saw, lowering clutch.
c	*ditto adjustment*...	Same as *b*.
D	*Moderating*	Air dash-pot on horizontal tail of see-saw.
E	*Replacement*.....	None required.
F	*Focusing*	None.
f	*ditto adjustment*...	None.
G	*Change-over*.....	None.
H	*Cut-out*.....	Insulated contact on lower end of see-saw, pulled over by shunt-coil, and puts cut-out resistance as shunt from + to − terminal.

THE BOARD OF TRADE INQUIRY ON THE LONDON ELECTRIC LIGHTING PROVISIONAL ORDERS.

In accordance with the notice issued by the President of the Board of Trade, Major Marindin opened an official inquiry on Wednesday, at the Westminster Town Hall, into the various applications for Electric Lighting Provisional Orders for the Metropolitan area.

Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham, appeared for the London Electric Supply Corporation; Mr. C. A. Cripps for the Metropolitan Electric Supply Company; Mr. Moulton, Q.C., and Mr. R. S. Wright for the Chelsea Electricity Supply Company; Mr. Muirhead for the St. James's and Pall Mall Electric Light Company; Mr. Roger W. Wallace for the Notting Hill Electric Light Company, for the Kensington and Knightsbridge Electric Lighting Company, and for the Westminster Electric Supply Corporation; Mr. Moulton, Q.C., and Dr. Hunter, M.P., for the Electrical Power Storage Company; Mr. G. Prior Goldney (the City Remembrancer) for the City of London; Mr. T. Percy Gunyon (engineer) and two members of the Council for the London County Council; Mr. C. A. Cripps and Mr. F. M. Jenkins for the Strand District Board of Works; Mr. Hopwood (solicitor) for the Holborn District Board of Works; Mr. E. Bayley (clerk) and Mr. G. W. Thompson (surveyor) for the St. Olave's District Board of Works; Mr. James Spencer for the Greenwich District Board of Works; Mr. J. H. Horton for the Paddington Vestry; Mr. Hitchins for the St. George's (Hanover-square) Vestry; Mr. Wilkins (clerk) and Mr. W. Jenkins (chairman of the Lighting Committee) for the St. James's (Westminster) Vestry; Mr. Webster Murnane (clerk) for the St. Martin's-in-the-Fields Vestry; Mr. T. Eccleston Gibb (clerk) and Prof. Robinson, C.E., for the St. Pancras Vestry; Mr. Cripps and Mr. Greenwell for the Marylebone Vestry; Mr. H. J. Smith (clerk) for the Lambeth Vestry; Mr. Harrison (solicitor) for the Bermondsey Vestry; Mr. E. Moore (solicitor) for the Great Eastern Railway Company; Messrs. Payne, Son and Pollock (solicitors) for the North London Railway Company.

Major MARINDIN said that in the first instance he proposed to consider the application of the London Electric Supply Corporation.

Mr. PEMBER, Q.C., then explained the nature of the order submitted by the London Electric Supply Corporation. With reference to the position of the company, he said it had an authorised capital of £1,250,000, of which about £800,000 was subscribed, the amount paid up being £585,000. The company had expended on works and plant £430,000, which left them in hand about £150,000. That theirs was a substantial undertaking their operations so far showed, and that they had not only got the money, but were expending it wisely and in a far-seeing way, and they had already gained considerable experience in electric lighting. Their system differed from those of other companies because, instead of having a separate generating station in each locality, they proposed to have one large station at Deptford, and to have trunk mains from it which would carry the light to London along the routes of the railway companies, with whom agreements had been entered into. Originally the order was much more comprehensive than it now was, for several districts had been deleted which were included at first. These were St. Mary Abbot's Kensington (part of), St. John's Hampstead, St. Mary's Islington, St. Leonard's Shoreditch, Paddington (part of), St. Luke's, St. George's-in-the-East, Whitechapel District; St. Mary Lambeth, and St. George-the-Martyr, Southwark. The following parishes still remained in the order: St. Martin-in-the-Fields, St. Margaret and St. John (united) Westminster, St. James Westminster, St. George Hanover-square, Chelsea, St. Mary-le-bone, St. Pancras, St. James and St. John (united) Clerkenwell, the Strand District, the St. Giles District, the Holborn District, the City of London and the liberties thereof, and the extra parochial places of Lincoln's Inn, Gray's Inn, and the Inner and Middle Temple, all in the County of Middlesex; the Greenwich District, in the County of Kent; the parishes of St. Mary Rotherhithe, St. Mary Newington, and St. Mary Bermondsey, the District of St. Olave, and the District of St. Saviour and Christchurch, all in the County of Surrey. The company did not ask for any exclusive grant of any district, and did not object to competitors, but were quite ready to see orders granted by the Board of Trade to any other persons within the same area. That being so, there were, he thought, two main questions of principle applicable to their case. First, was it advisable to grant a large area to one company? and secondly, was it advisable to give more than one company powers over the same area? Of course they answered "Yes" to both questions. Competition had obviously been intended by Parliament. He remembered perfectly well that Mr. Stanhope's Committee of 1882 discussed the question of Competition *versus* Regulated Monopoly, and they rejected the principle of monopoly such as had taken place in the case of the Gas Acts, and preferred to leave the matter open, and it was for that reason that they had fixed no maximum price for electricity in the Act of 1882. It would be obvious that if that was the principle upon which Parliament proceeded, the Board of Trade, at all events, should be open to consider the question of unlimited competition in one area. If that was admitted, and if that question was answered in the affirmative by the Board of Trade, it was clear that the first question would also be answered in the affirmative, because, if it was held to be advisable to give more than one company powers over the same area, there would be no harm whatever in giving to the company who applied for it as large an area as it thought fit to cover. The possession of a large area over which they could expatiate, and in which they could employ profitably their capital, would be a great encouragement to the investment and consequent cheapening of supply. There was, at all events, nothing in the Electric Lighting Acts of 1882 and 1888 to prevent the Board of Trade giving effect to this view: that Board had a perfectly free hand, and he hoped they would use it. After describing the company's works at Deptford, the learned counsel invited Major Marindin to pay them a visit before the termination of the inquiry. The works were large and compact, and thoroughly well considered, and they were a largely-devised attempt on the part of the company, who hoped to be one of the largest purveyors in London, to do something analogous to what had been done by the gas companies—when they moved from London to Beckton—for the public of London. They hoped that before long Deptford would become an electrical Beckton. The intended plant of the company would consist of four double engines and dynamos of 10,000 horse-power each, and there would be two smaller engines, each of 1,500 horse-power, and these two smaller ones would be ready for use a month hence. The first of the large ones would be ready by November next, and the second one in December, probably. A supply of 230,000 lights could be given constantly by these engines. If necessary they could be duplicated very speedily, and it was not too much to say, in fact, that the plant could be multiplied yet further on the existing premises of the company, and if called upon to do so the company could give a daily supply of 1,000,000 lights. To carry out their scheme of having trunk mains to London they had arranged with the London, Brighton and South Coast Railway Company, the London, Chatham and Dover Company, the Metropolitan Railway Company, and the South-Eastern Railway Company—his company's works were situated near the South-Eastern Railway at Deptford—for the mains to be carried along their lines and bridges, which would enable them to avoid breaking up suburban streets. The current when it was thus brought to London would be distributed to various stations, where it would be connected from the high pressure at which it was brought into low pressure for the private houses; and would then be distributed by ordinary supply wires to the private customers. The advantage of this over other systems was the removal of different generating stations out of town to one place in the suburbs. That would be a great advantage to all parishes concerned. It would remove the nuisance of the noise of moving machinery. There would be no smoke, or carriage of coal through the streets, and the absence of the manufactory itself must obviously be a great boon to everybody, for it was conceded that the nuisance from existing stations in the metropolis—at Paddington, Jermyn-street, and the Grosvenor Gallery—had been very great. It had only been by assuring people that it was intended to apply for this Provisional Order and to move to Deptford that his company had avoided lawsuits. With regard to the coal cartage, if a parish were taken having 200,000 inhabitants, and they were allowed 200,000 electric lights, one light per head, then for the production of those lights 408 tons of coal per day would be required. That was on the assumption that condensing engines would not be used in populous places. To carry these 408 tons of coal each day 200 cartloads would be necessary, and there would be other carts required for the removal of ashes and waste and for the cartage of oil, and that cartage would be a serious addition to the heavy traffic of a crowded parish. It would cause serious obstruction. Sufficient coal storage would not, moreover, be practicable in separate parishes, and a snowstorm or a fog might be the cause of a parish being left in temporary darkness through the traffic for the supply of coal being stopped. The cheaper land to be had in the suburbs, and the unity of management resulting from concentration of works, would further add to the economic gain to be obtained. The company's works were also on a river frontage, and the company could bring their own coal direct in their own steamers to their own wharf, and this would reduce the cost of coal from 20s. or 25s. to 12s. or 15s. a ton. All these things would tend to the benefit of the consumer. And, finally, they had abundant water at their command there, and could use condensing engines, which would further tend to cheapness of production. The relative advantages of this company's system would be further explained by their engineer, Mr. Ferranti. The distributing mains would be comparatively small one capable of conveying power for 100,000 lights occupying only a space of 2¼in. diameter. This smallness of the tubes reduced the breaking up of streets to a minimum, and the company were perfectly ready to co-operate with any other company who might be serving the same district on that point, which would secure joint opening of the streets. The learned counsel then touched upon the applications for other orders, and the attitude of their promoters towards his clients. Besides the orders, two licenses were applied for—one by the Chelsea Electricity Supply Company and

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one by the House-to-House Electric Light Supply Company; and he invited Major Marindin to consider these matters solely as they affected the London Electric Supply Corporation. The London Electric Supply Corporation only opposed the other applications conditionally; it had no objection to them. The other methods did not affect them except on the consideration that only one company should be allowed on one area, and, if that was to be the rule laid down by the Board of Trade, then his company would oppose all those applications, contending that their own system was the best, and asking that it should be the one authorised. If competition was admitted, they were so confident of the superiority of their system that they would have no fear of the presence of any number of competitors.

He would now select typical examples of the objections lodged by the various parties, to show the general scope of the opposition. First, it was urged that the period settled by Parliament last year of forty-two years as the term for the acquisition of the undertakings by local authorities should be reduced to twenty-one years, which was the period fixed by the Act of 1882. His reply to this was that Parliament and everybody concerned had felt that twenty-one years was too short, and that that limitation had crippled enterprise. The Earl of Camperdown's Select Committee in 1886 took overwhelming evidence to that effect, and the Board of Trade would not be likely to go back to that limitation. A local authority might be anxious to get hold of a profitable undertaking on easy terms, but Parliament had held the scales between such local authorities and the undertakers, and had determined not to allow it. That was the meaning of the 1888 legislation as against the 1882 legislation. The St. James's, Westminster, Vestry proposed the insertion of a clause forbidding one company acquiring or associating itself with another undertaking in the same district, which was more than they were entitled to ask, there being already legislative provision upon the point. It was an open question at present whether undertakers under a Provisional Order should or should not be allowed to transfer their undertaking. He saw nothing in the Acts of 1882 and 1888 giving express power to do so. It was at any rate a matter to be settled by the supreme authority, and not by a local authority, and the Board of Trade was abundantly safeguarded against any improper transfer. Then it was also suggested that the company should provide in some way a pecuniary deposit, he supposed as a guarantee that they would carry out the work. This was a question of degree. If it were a question of depositing some not very large amount, say, £10,000 or £20,000, in respect of the whole order, the company might not raise any great objection; but to give more than that—to give a sum of £500,000 as had been suggested, for every parish—would be a very serious matter, and a course that would seriously hamper the finances of any company, however sound its position might be. He did not think it would be recommended by the Board of Trade. It would be against public policy to lock up a sum of money like that, which might be well employed in the furtherance of the order itself. Next, there was a proposal for a provision prohibiting the connection of a circuit with the earth, which was not a question to be decided by local authorities, but, once for all, by the Board of Trade, acting upon the advice of its scientific advisers. Then it was suggested that the local authority should have the approving of the distribution boxes, as to their size and pattern. His objection to that was that it would give the local authority undue control over matters upon which they were not very well qualified to form a judgment. These boxes would be comparatively small.

A more important matter was that of overhead wires, and the proposal was made to insert words to the effect that an order was to confer no powers to erect overhead wires, to which he should not object if that were all, but he should strenuously object to the words going further. At the present moment he believed that the company had, in common with a good many telegraph and telephone companies, a common-law right in this matter, and could put up overhead wires, having got the consent of owners and occupiers, provided the wires were carried at a sufficient height to take them from house to house, and such wires existed in great numbers over London streets. The Telephone Company, he believed, did all its business in that way, and he should strongly resist any words being inserted which would have the effect of controlling or limiting their present legal rights in that respect. They were, however, perfectly ready to have words inserted that the order should confer no such power. The following agreed words had been put into several Provisional Orders already:—

"*Nothing in this order shall authorise the undertakers to place electric light wires above ground, along, or over, or across any street, without the express consent of the local authority.*"

To that extent his company had no objection to the proposed amendment, but beyond that they would not go. There were some other objections which he would prefer to leave to the determination of the Board of Trade arbitrator. The Company sought to be exempted from the provisions of the Building Act of 1855. The City of London took the view that they were in an exceptional position, having powers under their own Acts of Parliament, which authorised them to grant the requisite facilities for electric light undertakings, and they declined to assent to any powers being given by Provisional Orders which would affect the area of the City of London. They had further elaborated a plan of their own for the lighting of the City by public tender. This plan the company considered was open to very grave objection, as they did not think that any electric lighting company which valued its position would accept the terms offered in the form of tender proposed by the City. They contended that the City was not in the sense claimed outside the Electric Lighting Acts, which defined local authorities, and among the local authorities there described he found the City of London and the liberties thereof defined as one, and he therefore failed to see that the City was exempted from the purview of the Acts. It would be for the Board of Trade to decide. He maintained that the dissent of a local authority could not be a veto. The Board of Trade had an undoubted right to grant the order now asked for, or any other order, against the wishes of a local authority.

The EARL OF CRAWFORD AND BALCARRES, Chairman of the London Electric Supply Corporation, examined by Mr. LOYD, said that the corporation had been formed to take over Sir Coutts Lindsay and Company (Limited), which was started in 1885. When the directors found that they had reached a point when the undertaking could not be carried on, they resolved to make it a larger affair, and the present company resulted, the directors remaining the same, and had the experience of five years. The directors, soon after they commenced, concluded that it would be very advantageous if they could get a position away from a populous area to supply the electricity from a distance. There had been eleven threatened injunctions altogether, some of which had been "squared," others fought, and others again they were fighting. The assurance that they were looking out for another place at a distance had induced others to stay their hands. He believed that both the Paddington and the Jermyn-street installations had been threatened in the same manner. They had capital to supply as much light as was likely to be required at first; they did not contemplate having to supply the whole area at first. The progress of the adoption of the light must be gradual, and the use of electricity as a motive power he believed would eventually throw lighting into the shade. The Deptford works had been arranged with a view to gradual development, and in a way that additions could be conveniently made. One of the smaller engines had been running last week under steam of 1,500 horse-power. They were also putting up two machines, engine and dynamo combined, of 5,000 horse-power. A second engine could be added to the same dynamo, giving a maximum output of 10,000 horse-power. The first one they hoped to have ready next August. With that amount of horse-power available each machine would give a current for 100,000 ten candle-power lamps. According to their experience of the smaller class of dynamos each would probably give a current for 120,000 lamps, and that would give a total of 240,000 lights. The distance it was proposed to carry the current under the present order was about seven miles, from Deptford to Chelsea, and there would be no difficulty whatever in transmitting the current with safety to life and property for that distance.

As to multiplicity of undertakings in one area, he was of opinion that, although it was of advantage to a company to have no competitor in the same area, it would be a distinct advantage to the public to have more than one. There would be less disturbance to the streets in laying the mains proposed than there was in laying the gas mains, and there was no reason why two mains should not be placed in close proximity. His company were entirely opposed to monopoly, and considered it to be contrary to the spirit of Parliament. They asked for no exclusive powers. If only one company was allowed in one area, then they considered that theirs would be the best system to be adopted.

Cross-examined by Mr. MOULTON: His company was bound to no system, but took the one they considered to be best; but it did not follow that any other company could adopt any method which they might take. Some were protected by patents. They proposed to adopt the transformer system. He had not gone into the details of the cost of thoroughly lighting all the streets in an area, but he would put it at 12s. 6d. a yard—1,100 miles at 12s. 6d. a yard. To state the whole cost he would require to be told how many lamps he had to supply, and, to guard against accident, a duplicate plant. The current would be carried into the houses at a pressure of 2,000 volts, but would be transformed down to 100 volts.

The witness was further cross-examined as to the means of working the system, both on the works at Deptford, at the distributing stations, and in the houses supplied.

Mr. GOLDNEY, the City Remembrancer, representing the Corporation, who also opposed, asked some questions, and the witness said that it was impossible to say how much of the company's capital, now raised to £1,250,000, would be necessary to work the City lighting. The company could not make such a calculation until they knew what they had to do, and they had not allocated any amount to any area. The company knew that if they needed more money they would be able to get it. The abandonment of applications by the company as regarded Islington, part of St. Margaret's Westminster, Whitechapel, and other places had nothing to do with capital. Paddington, Hampstead, Shoreditch, and other places were taken off in order that the Board of Trade should not consider the company was asking for too large an order.

The inquiry was adjourned until the following day.

THURSDAY.

On the resumption of the inquiry on Thursday Lord CRAWFORD was further cross-examined by Mr. GOLDNEY, in reply to whom he stated that he considered that the City of London should come under the Provisional Order, inasmuch as it was included in the schedule to the Acts. The London Supply Company proposed to enter the City at Cannon-street and at Ludgate Hill, and they hoped eventually to enter at a point further east. The area of the City was important to the company, because the greater part of the lighting there would be done in the day time. They were prepared to supply either arc or incandescent lighting, according to what the City was prepared to pay. The specification issued by the Commissioners of Sewers for tenders showed that in the three districts there were respectively 388, 526 and 633 gas burners—altogether 1,500 burners. Five hundred arc lights would supplant those gas burners. He had not worked out a complete scheme for the City because he did not wish to waste time in making a hypothetical scheme which the order might at once upset. His company were prepared to supply the City on as good terms as they would give to any other consumers; but he could not tell what tenders the company might make. He certainly would not give a supply on the terms proposed in the Commissioners' specification, and considered them unfair to everybody. He apprehended that the

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Commissioners were not empowered to say whether or not a company should supply the City, but that that was a matter for the Board of Trade.

In reply to Mr. CRIPPS, who represented the Metropolitan Electric Supply Company, Lord CRAWFORD said it was his conviction that it was more economical to buy electric light from one large station than from several small stations, as under the system of the Metropolitan Company. With regard to the question of cheapness of coal through the convenience of site, he was aware that cheaper coal than navigation coal could be used, with modern appliances, without causing any smoke nuisance, but not without the nuisance of noise. His company had tried the modern appliances, but they had failed to work satisfactorily because they could not get rid of the noise. He was aware that there was a station working in Whitehall, but it was on private ground, and the only neighbour was the Hotel Metropole, and as engines were also at work there, no complaint as to noise could be made on either side. The Whitehall Station was a very limited one, and the London Company could not work in the same way.

Replying to Mr. SHIRESS WILL, representing the House-to-House Supply Company, Lord CRAWFORD declined to state how much of the half million that his company had expended on works had been expended at Deptford, not considering himself called upon to produce his balance-sheet. Referring to the plant at Deptford, he explained that they had unit machines in the same way as that proposed by the House-to-House Company, but their unit was larger than others, and they kept a spare unit in reserve in case of a breakdown.

Mr. S. WILL, Q.C., M.P., appearing on behalf of the House-to-House Company, said he proposed to put a few questions as to the policy of one large company being in opposition to several small ones.

A technical objection was raised on the ground that the company was not before the inquiry, but eventually it was allowed.

Lord CRAWFORD, in reply, said his corporation proposed to take a large area, and to commence over the whole ground at once. He could not give an estimate as to what the whole cost of the complete work would be, and until he knew the number of miles to be opened at first he could not tell what the initial cost would be of starting at all these places together. It was proposed to open 18 centres. A mile of mains from each of these centres would cost altogether, he estimated £30,000, and an additional 12s. 6d. a yard for excavation.

In reply to the representative of the Vestry of St. James, Westminster, Lord CRAWFORD said he was of opinion that the application of electricity as a means of motive power would become in a short time quite as much in request as its application to lighting, and his Corporation hoped to be able to apply electricity to motive power. They had made no provision for a day's storage, and in view of a strike of all the stokers it would have the effect of putting London in darkness; but they had got a special Act, and the stokers would also come under the Gas Act. The *contretemps* was possible to the Corporation, but it was also possible to any other company. He bowed to the authority of the London County Council. He believed in friendly competition among the electric light companies.

Lord Crawford was also cross-examined by representatives of other local authorities.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March 23rd*, 1889.

An important decision was rendered this week by Judge Coxe, of the United States Circuit Court for the Southern District of New York, which bears directly upon the use of the accumulator in this country. The Electrical Accumulator Company, owning the Faure, Swan, and other patents, had sued the Julien Electric Company for infringement of the same. The judge, after a very long and exhaustive review of the case, has decided that the Electrical Accumulator Company is not entitled to the broad construction of the claim of Faure of the application of an active material to the plate of a storage battery; but on filing a disclaimer, limiting the first claim of the Faure patent to an electrode of a secondary battery to which the active layer is applied in the form of a *paste*, *paint*, or *cement*, it will be entitled to a decree for and injunction, and an accounting upon the same as thus limited, but without costs. Regarding the patent of Swan, which related to the perforations in the electrode of the secondary battery, the judge held the same to be invalid, due to prior work, which was shown during the trial. The application of the active material other than in the form above-mentioned is therefore held to be no infringement of the Faure patent, and as the Julien Company now claim that they do not apply the active material in any such form, they would appear not to infringe the patent at all. We shall probably learn more about this, especially as it is claimed that the man most benefited by the decision is Mr. C. F. Brush, who holds important patents in this field.

Some very interesting figures have just been compiled by the *Progressive Age* of this city, a journal devoted comprehensively to gas and other lighting interests, showing the number of gas companies in this country operating electric light plants. A list of the same kind was published by the same paper last October, from which it appeared that there were then 150 gas companies, operating 12,834 arc light, of 13 different systems. The present list shows a remarkable gain, there being no fewer than 266 companies, operating a total of 21,313 arc lights, and 55,890 incandescents, representing no fewer than 21 different systems. These figures are approximate, but if anything should be larger, some of the companies having failed to go into details. The result shown is a remarkable exemplification of the change of front on the part of the gas companies, a change that is undoubtedly due in no small measure to the work of the paper in question, which has been incessant and unremitting in its advocacy of a combination of the two interests, gas and electricity. Going into the details of the figures, it appears that the gas companies are operating 11,084 arcs of the Thomson-Houston system, and 8,826 incandescents. The Brush Company comes next with 3,964 arcs, the American next with 1,813. Of incandescents there are also 27,710 Westinghouse, and 10,256 Edison.

This matter, as to the combination of gas and electricity, is touched on in a very interesting way in a book which has just been published by Mr. A. R. Foote, of Cincinnati, entitled "The Economic Value of Electric Light and Power." Before I go on to mention the leading subject of this timely work, I may note that several well-known gasmen are quoted as to the desirability of operating gas and electric light plants together. It is not a little amusing to find among these authorities General A. Hickenlooper, the president of the Cincinnati Gas Light and Coke Company. Only a few years ago—three or four at the most—General Hickenlooper was fighting the electric light tooth and nail, and tongue too. He was not merely satisfied with opposing it locally, but took the trouble to collate a large number of alleged electric light accidents and failures, and put them all together in the Cincinnati daily papers, which were then scattered broadcast all over the country. More than this, the General took occasion to reprint this literary masterpiece in pamphlet form and to constitute himself a tract society for its free and liberal distribution. But the times have changed and Hickenlooper with them, and now we find him saying, "I think the time has come when the electric and gas interests should be united to perform the service of supplying cities and towns with light, heat and power." Another authority quoted is Mr. T. Turner, president of the Gas Light Association, who deprecates as a mistaken policy that so often pursued by gas companies and engineers, of fighting the electric light.

But the main point brought forward by Mr. Foote is the question of whether it is well for cities to own and operate their own electric light plant. This is a vital topic at the present time, because on every hand we see large numbers of cities investing the proceeds of local taxation in the purchase of electric plants, some large and some small, and all on the plea of obtaining economy and effecting a saving to the city. Mr. Foote, who read a very forcible Paper against this tendency at the recent meeting of the National Electric Light Association, now prefaces his book with a section of some fifty pages, devoted to a discussion of the same topic. Mr. Foote there takes occasion to point out the mistakes made and the erroneous arguments used in pushing this policy, and advocates as an alternative that each city should grant an exclusive franchise, under strict and rigid conditions, to one local company for the supply of electric light and power. On its side the company shall guarantee putting in a plant capable of performing all the service required, and in return it shall hold its franchise for a given number of years, so that this investment, at least during that period, will be permanent and free from disturbance, whether by competition or by the sudden withdrawal of city contracts. Mr. Foote believes that in return for such a franchise as this a great many cities would obtain their own street lighting on very low terms, much lower, in fact,

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than if it went into the business itself. I have no doubt that Mr. Foote's little book will find a great many readers, and it seems likely to have a good deal of influence at this time.

News comes from Boston of the great interest being taken there in the Thomson Electric Welding Company. The stock is in brisk demand, and I think I have already mentioned that very good results have been obtained with the latest forms of apparatus. Prof. Elihu Thomson has lately built a new alternating-current dynamo, the object of which is to obtain the magnetic field as rapidly as possible. This not only saves time, but is very desirable from the fact that it is often necessary to have a rapid building up of the field for good work. In this new machine, so rapidly do the fields build, that in welding a 2in. piece, from the time that the rheostat is set till the fields have become thoroughly saturated is but 2sec. The machine is wound for 300 volts potential, and with a current capacity for welding 2½in. solid iron will give 125 amperes at that voltage. A very interesting series of experiments is now being made at the factory of the company at Lynn, in order, if possible, to arrive at some law governing the amount of energy required to weld the different sizes of the same material. It appears that there is quite an extraordinary variation in the time and the quantity required. It is found, for example, that in welding ½in. wrought iron about 10 horse-power is required for some 8 or 10 seconds, whereas in welding 1in. iron 20 horse-power is required for 40sec.; but even these figures do not appear to bear any relation to any others. As is already known, the energy represented is mainly accounted for by the volume of current flowing. With 1in. iron, for instance, there will be some seven or eight thousand amperes at considerably less than half a volt E.M.F. This is certainly an interesting field of investigation, and at the hands of Prof. Thomson will be sure to bring out some interesting effects.

Speaking of the activity in Thomson welding stock reminds me of the fact that latterly there has been no less activity in the stock of the Thomson-Houston Electric Company, which, as everybody knows, devoted itself to light and power. In the hands of Mr. C. A. Coffin this company has attained a marvellous development. In 1883 it had 22 sub-companies, operating about 1,500 arc lamps. To-day it has nearly 450 operating over 50,000 lamps, while 175 companies are doing an incandescent business and running about 100,000 lamps. In the electric railway business the company has already made great strides, and it has now some 30 or 40 roads in operation; in fact, it is reported that the company did a total business of about $4,000,000 in 1888, at a profit of $1,200,000, and that it has a business in sight for 1889 of not less than $7,000,000. It can readily be understood that on such figures as these the stock of the company is held at rapidly advancing figures. According to statements from Boston, the manner in which stockholders in the company enjoy handsome profits, even when no dividends are paid, is an ingenious and interesting one. The method consists in taking the shares of various sub-companies organised to use the Thomson-Houston system and placing them in a pool. The certificates in this pool are then offered to the shareholders at a certain figure. This figure not only allows the parent company a handsome profit, but in view of the price that the certificates fetch in the open market, and the return of them from the interest paid by the various local companies, there is a handsome dividend to the shareholders as well. Thus, for instance, the shares in series C of the pool certificates offered to stockholders for $10 were soon sold at $18, and probably could not be obtained now for less than $20. Hence the right to take these pool certificates is of considerable value, and the stockholders stand to make an excellent dividend. It is evidently a great deal better policy thus to mass these securities of the local companies and place them in a pool which sells at a good figure than to dump them at haphazard on the open market, that does not have a fair appreciation of their value, and where they might often go begging. There is no question as to the shrewdness of the business policy that has governed the Thomson-Houston management, and the company seems to have been fortunate not only on this respect, but in the technical skill that it has commanded from the start.

While we thus find the affairs of one of the youngest of the great electric companies in excellent condition, it is to be noted that the old Western Union is still pursuing the even tenor of its way, and paying substantial dividends. The returns from this vast property are now about as steady and as fair as those of any other large property entrusted to the mercies of the stock market, and there seems to be no good reason why the company should not go on paying higher and better dividends for some time to come. At the present rate of 6 per cent. per annum the company is able to add to its surplus $2,000,000 or $3,000,000 a year, and there are a great many stockholders who would like to see the rate of dividend increased. It is a little bit singular, by the way, that while the newer electrical companies on a large scale find it to their advantage to secure all the first-class technical talent that they can, the Western Union of late seems to have convinced itself that it can get along without any such talent at all. Not long ago the company relinquished the services of Mr. G. A. Hamilton, who has been with it so long. How the company can allow so good a man to leave it is what very few of us can understand, but there is no doubt that Mr. Hamilton will be warmly welcomed in the ranks of the Western Electric Company, which he joins. As I need hardly remind you, the Western Electric Company does all the heavy manufacturing for the telephone business of this country. It also has a good electric light system, and goes in largely for miscellaneous work. It has a huge factory in Chicago, and has just finished one in this city; hence it is a good field for an electrical expert such as Mr. Hamilton, but it seems to an outsider that there should have been plenty of work for that gentleman amid his old associations.

There is considerable activity at the present time in the storage battery field here, and large numbers of cells are being sold, not only for lighting, but for traction. An interesting report comes this week from Detroit of tests made there with the Detroit storage battery of the Woodward Electrical Company. It appears that a car equipped with this battery and furnished with a motor, &c., made by Mr. F. B. Rae, ran very successfully on March 13 on the Highland Park Railroad. With 84 cells, rated at 300 amperes, the cars made eleven round trips, carrying passengers in the regular way, making a speed of from ten to eleven miles an hour, and running 80 miles. This was done on one charge of battery, and four 16 candle-power lights were run from the cells after dark; and in addition to that next day it was found that the E.M.F. of the cells was still up to two volts, and that there was current enough for another trip or two. These strike one as pretty good results, and if they can only be maintained the Detroit Battery Company will certainly be heard from again. It will be remembered that this battery is made by taking a mixture of salt and lead, which is cut into plates of the desired thickness, out of which the salt is dissolved, leaving the plate full of holes of irregular shape throughout. In these pores a paste of oxide of lead is put in the regular way, after which the plates are formed, and are then ready for use. According to tests made by the John Hopkins University of this battery lately, under Drs. Louis Duncan and G. A. Liebig, the efficiency of the battery reached as high as 75 to 80 per cent.

There appears to be a general feeling of real pleasure in electrical circles at the smash up of the French copper syndicate. The corner of the Copper Market has had a seriously detrimental effect on electrical industries here for some time, not only crippling old concerns but causing new ones to hold back. I could mention several instances in which the high prices of copper has interfered with extensive electric light operations, and now that the market has gone back to something like a normal condition we shall undoubtedly see greater activity all round. It may perhaps take some time to have trade falling into its regular channel, and to get prices on the right basis, but when we find copper here down again to 11 or 12 cents a pound we know pretty well that the days of the copper corner are ended. It is publicly stated that the price of laying down good copper in this city from the Tamarack mines in 1887 was only 5¾ cents a pound, and 7 cents from the Calumet and Hecla, so that those companies must have been doing pretty well with rates up to 14 and 15 cents a pound.

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CORRESPONDENCE.

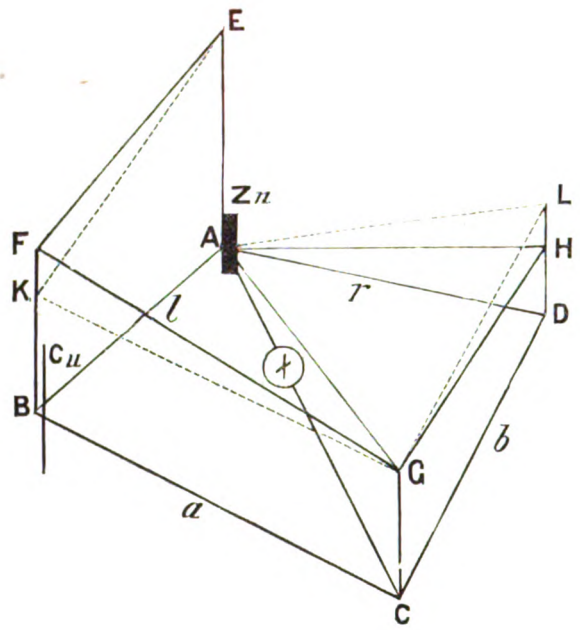
MANCE'S BATTERY RESISTANCE TEST.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following simple proof of Mance's method of finding battery resistances may be of interest :—

The figure represents a perspective view of the bridge and of the currents in the various branches. A B is the arm containing the battery whose resistance l is to be measured. Let the resistances in the other arms be represented by a, b, and r. A E, B F, C G, and D H are drawn perpendicular to the plane A B C D, and their lengths represent the potentials of the points A, B, C and D, before the connection between B and D is made. The potential A E is that of the surface of the liquid in contact with the zinc plate, the potential of the zinc plate itself being considered zero.

When the connection between B and D is made the potential of B will fall and that of D will rise ; but if the balance is properly adjusted the potential of C will not be affected since the current in the galvanometer is unaltered.



The currents in the arms of the bridge are now represented by the dotted lines E K, K G, G L, L A. The current in b will be decreased. If the connection between B and D has less than a certain resistance $\left(\frac{a\,r}{g}\right)$ this current will be reversed.

Now let C_a, C_b, C_l, C_r be the currents in the branches before the connection B D is made, and let C'_a, C'_b, C'_l, C'_r be the currents after B D is closed, and let C_g be the current in the galvanometer, then

$$\begin{aligned} C_g &= C_a - C_b, \\ &= C'_a \pm C'_b, \\ &= C_l - C_r, \\ &= C'_l - C'_r ; \end{aligned}$$

therefore $$C_a - C'_a = C_b \pm C'_b,$$

and $$C'_l - C_l = C'_r - C_r ;$$

but $$C_a - C'_a = \frac{F\,K}{a},$$

$$C_b \pm C'_b = \frac{L\,H}{b},$$

$$C'_l - C_l = \frac{F\,K}{l},$$

$$C'_r - C_r = \frac{L\,H}{r} ;$$

therefore $$\frac{F\,K}{a} = \frac{L\,H}{b},$$

and $$\frac{F\,K}{l} = \frac{L\,H}{r},$$

dividing one equation by the other we get $\frac{l}{a} = \frac{r}{b}$, or $l : a :: r : b$.

It will be observed that the proof is independent of the assumption that the potentials of B and D are equalised on connecting them together, which shows that the insertion of a resistance between them is as efficacious as short-circuiting them—a result found to be the case experimentally. The resistance between B and D may vary between 0 and ∞ without altering the value of C_g if $l : a :: r : b$. The less the resistance, however, the better the test.—Yours, &c.,

R. L. HIPPISLEY, Capt. R.E.

Chatham, April 2, 1889.

THE USE OF FEEDERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your notes of last week on Prof. Forbes' Paper on "Central Station Lighting," you say that you are not aware of "a single instance of the use of feeders in this country at the present time." In our system of underground mains in Liverpool, which has been in daily operation since December, 1888, we have made extensive use of feeders. Our mains now extend over an area nearly one mile long and half a mile wide, and more than four thousand lamps are connected to our wires, the current being supplied from three central stations. The whole of our supply is measured and charged by meter.

We venture to think Prof. Forbes deserves the thanks of the electric lighting community, as it is obvious he does a more valuable work in collecting and bringing to our notice experience from abroad than he could do by ascertaining and publishing what has been done in his own country.—Yours, &c.,

Liverpool, April 2, 1889. HOLMES AND VAUDREY.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 2, 1889.

3,687. W. J. S. BARBER-STARKEY and F. G. HOWARD. London. Improvements in apparatus for establishing electrical connection, and also for breaking the same at will at any desired distance from the operator.

3,697. J. A. KINGDON. London. Improvements in the construction and application of transformers for the distribution of electricity for lighting and other purposes.

3,708. J. KENT. London. An improved method for joining electric conductors.

3,730. H. M. GOODMAN. London. Improvements in apparatus for use with cables when it is desired to establish electrical communication between a moored lightship or other vessel and some place at a distance therefrom, whether on shore or otherwise.

March 4, 1889.

3,761. H. C. L. HOLDEN. Woolwich. Improvements in electric tubes and fuses for firing ordnance and exploding torpedoes and mines and for like purposes.

March 5, 1889.

3,808. J. C. RICKETSON. London. Improvements in electric signals for engine shafts.

3,813. A. R. BENNETT. Glasgow. Improvements in telephonic switching apparatus.

3,835. E. BÖHM. Shepherd's Bush. A new or improved incandescent electric lamp.

3,836. L. HANSON. Halifax. Improvements in electric arc lamps.

3,841. W. P. THOMPSON. Liverpool. Improvements in or relating to regulators for systems of electrical distribution (The Westinghouse Electric Co., United States).

3,870. H. H. LAKE. London. Improvements in electric-motors and dynamo electric machines (O. Lugo, United States).

3,881. J. W. BALET. London. Improvements in the method of and apparatus for regulating electric currents.

March 6, 1889.

3,889. F. G. HOWARD and A. J. OBERMAYER, jun. London. Apparatus for opening or closing the shutter of a photographic camera by means of electricity.

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3,907. T. Parker and E. S. G. Rees. Manchester. Improvements in electrical switches.
3,940. G. A. Schoth. London. Improvements in galvanic batteries.
3,954. P. M. Justice. London. Improvements in electric signalling systems and apparatus for railways (T. P. Worrall, United States).
3,971. J. J. Rathbone. London. Improved compound or admixture of ingredients suitable for producing electric energy.

March 7, 1889.

3,987. A. Wright and G. J. Philpott. Brighton. Improvements in measuring and regulating instruments.
3,990. W. P. Thompson. Liverpool. Improvements in dynamo-electric machines, whether generators or motors (La Compagnie Continentale Edison, France).
4,004. R. H. Courtenay. London. Improvements in electric apparatus which may be combined with mechanical apparatus for the transmission of sound. The combined apparatus may also be applied to other useful purposes.
4,029. G. Wilkinson. London. Improvements in the distribution of electric energy.

March 8, 1889.

4,029. W. F. Smith and J. Sinclair. London. Improvements relating to electric lamps.
4,125. W. O. Rooper. London. Improvements in holders for incandescent electric lamps.

March 9, 1889.

4,171. W. L. Wise. London. Improvements in accumulators or secondary batteries (F. C. Glazer, Germany).
4,192. Siemens Brothers and Co., Limited. London. A new or improved regulator for transformed electric currents (A. M. Taylor, India).

March 11, 1889.

4,208. H. T. Harris and A. Gay. London. The automatic regulation of E.M.F. or current in dynamo machines.
4,235. J. Conte. London. Improvements in coin-freed dynamo-metric apparatus.
4,250. J. E. Spagnoletti and J. Crookes. London. Improvements in apparatus for attaching and superseding electric lamps.

March 12, 1889.

4,287. J. W. King. London. Improvements in instruments for measuring electric currents.
4,296. J. Kynoch. London. Improvements in galvanic batteries.
4,336. T. Spencer. London. Improvements in electrical switches (H. T. Paiste, United States).

March 13, 1889.

4,371. G. Hookham. Birmingham. Improvements in electricity meters, parts of such improvements being applicable to electrical clocks and other electrical instruments.
4,407. H. E. M. D. C. Upton. London. Improved method of and means for code signalling with electric telegraphs.

March 14, 1889.

4,448. F. E. Elmore. Cockermouth. Improvements in or pertaining to incandescent electric lamps.

March 15, 1889.

4,518. G. Shackleton. Bradford. Improvements in apparatus for electrically regulating the "drag" on the fibres during the operation of spinning and twisting.
4,519. W. Hartnell. London. Improvements in electric cranes and hoists.
4,530. H. S. Price and H. J. Dowsing. London. Improvements in coin-freed apparatus for obtaining a current of electricity during definite periods of time for producing electric light and for other purposes.
4,559. D. G. Fitzgerald. London. Improvements in voltaic batteries.
4,566. W. L. Preece and J. Sayers. London. An improved method of distributing electricity for lighting purposes.
4,569. W. F. Dennis. London. Improvements in metallic telegraph poles.

March 16, 1889.

4,586. A. Milton, H. W. Bishop and F. Brown. Walsall. An electric light switch.
4,586. S. Naylor. Halifax. A portable electric alarm clock.
4,623. J. Farquharson. London. An improved metal reflector for electric search lights used in ships of war.
4,642. E. A. G. Street. London. Improvements in apparatus for measuring and registering the consumption of electric energy.
4,654. J. Caudray. London. Improvements in meters for electricity.
4,656. H. Tomlinson. London. Improvements in electric signal apparatus.
4,657. J. M. Napier. London. Improvements in electrical weighing machines.

March 18, 1889.

4,722. H. H. Lake. London. Improvements in coupling devices for electric conductors (A. C. Griggs, United States).

March 19, 1889.

4,800. H. H. Lake. London. Improvements in electric conductors (A. A. Brooks, United States).
4,748. W. Howson. Sheffield. Improvements in electrical and automatic appliances and methods for manipulating aeronautic balloon batteries in conjunction with aerostatic indicating, fulminating, and fumigating repeating magazine batteries, and in shells for same, for the purposes of warfare.
4,821. L. de Stein, A. Podhorzer and F. H. Bachmann. London. Automatic electric induction apparatus.

SPECIFICATIONS PUBLISHED.

1881.

1,240. Brewer. Armatures for electric machines. (Price 8d.) Second Edition.

1877.

1,996. Jablochkoff. Producing and dividing electric light. (Price 8d.) Fifth Edition.

1888.

224. Lorrain. Electric-measuring apparatus. (Price 1s. 6d.)
2,130. Muirhead. Electric telegraphs. (Price 8d.)
2,313. De Ferranti. Dynamo-electrical machines. (Price 11d.)
2,313a. De Ferranti. Dynamo-electrical machines. (Price 8d.)
2,314. De Ferranti. Electrical safety fuses. (Price 8d.)
2,315. De Ferranti. Electrical mains. (Price 8d.)
2,316. De Ferranti. Dynamo-electrical machines. (Price 2s.)
2,420. Scott and Paris. Regulating electric currents. (Price 8d.)
2,654. Kingdon. Dynamo-electric machines. (Price 8d.)
3,328. Langdon-Davies. Electric contact-makers, &c. (Price 8d.)
3,550. Thompson. Electrical battery. (Price 6d.)
4,270. Fiske. Electro-dynamic motors. (Price 11d.)
4,294. Myall. (Judd.) Harmonic commutator for alternating currents. (Price 8d.)
4,425. Charles and others. Dynamo-electric machines. (Price 8d.)
4,568. Williams. Electrical conductors. (Price 6d.)
4,764. Fry. Medical galvanic batteries. (Price 8d.)
5,082. Sellon and Jackson. Electricity meters. (Price 8d.)
5,196. Smith. Electric rail, &c., systems. (Price 1s. 1d.)
5,201. Davies and Fourtel. Coin-freed apparatus for electric light. (Price 11d.)
5,259. Capek. Electrically heating rooms. (Price 8d.)
5,528. Hermite and others. Voltaic batteries. (Price 4d.)
5,452. Cunnington. Protecting electric circuits. (Price 8d.)
5,786. Cashel. Clips for telephones, &c. (Price 8d.)
5,790. Steinach. Porous surfaces for electro-metallurgic deposits. (Price 6d.)
5,898. Chadburn. Vessels' telegraph apparatus. (Price 11d.)
5,899. Chadburn. Ships' engine-room telegraphs. (Price 8d.)
8,354. Leclanché. Depolarizers for batteries. (Price 6d.)
6,046. Treuenfield. Jointer for electrical conductors. (Price 8d.)
6,214. Farquhar. Laying underground electric conductors. (Price 8d.)
6,322. D'Humy. Galvanic batteries. (Price 8d.)
7,355. Treuenfeld. Field telegraph conductors. (Price 4d.)
13,145. Böhm. Incandescent electric lamps. (Price 8d.)
16,048. Thompson (Thompson). Secondary batteries. (Price 8d.)
16,959. Hilkier. Automatic electric contact apparatus. (Price 8d.)
17,223. Paget. Secondary batteries, &c. (Price 8d.)
17,224. Paget. Electrically propelling vehicles. (Price 8d.)
17,225. Paget. Generating electricity, &c. (Price 8d.)
18,245. Coerper. Electric lamps. (Price 8d.)
18,416. Jacquemier. Measuring electricity. (Price 1s. 8d.)

1889.

46. Roberts and Mollison. Thermo-electric generator. (Price 8d.)
118. Widdifield and Bowman. Electric brakes for railway trains. (Price 8d.)
189. Knight. Dynamo-electric machines. (Price 8d.)
278. Wehr. Lightning arrestor for telegraphs. (Price 6d.)
292. Luck. Electrical alarm thermometers. (Price 6d.)
319. Kookogey. Storage batteries. (Price 8d.)
320. Kookogey. Galvanic battery compounds. (Price 4d.)
434. Mehner. Dry galvanic cells. (Price 4d.)
516. Lake (Law). Electrical switches. (Price 11d.)
759. Wells. Electric railway switches. (Price 8d.)

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of March amounted to £55,187, and to £54,376 in the corresponding period of 1888.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic returns of this company for the month of March, 1889, amounted to £21,000. From the 1st January to 31st March, 1889, they were £63,000, against, in the corresponding months of 1887 and 1888, £61,200 and £63,800 respectively.

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LEGAL INTELLIGENCE.

Chamberlain v. The Midland Electric Light Company.

A motion to rectify the register of this Company by striking off the name of Mr. Arthur Chamberlain, of Birmingham, as the holder of 2,074 shares of £10 each came before Mr. Justice North in the Chancery Division last week.—Mr. Birrell, in support of the motion, said that there was no contest as to the facts of the case. The only question was whether or not, having regard to the circumstances under which those shares were issued, it amounted to an issue of shares at a discount. The point turned upon a clause of an agreement dated April 4, 1887, by which the Company assumed the liability and undertook to repay all moneys Mr. Chamberlain might advance for the purposes of the Company, an account to be struck on the 31st of December, 1887; and that all moneys owing should be repaid, together with interest at 15 per cent. When the balance was struck it was found that the Company was indebted to Mr. Chamberlain in a sum of £18,041. 5s. 11d., which, with the interest, amounted to £20,740. Mr. Chamberlain elected to take shares instead of cash, and accordingly 2,074 £10 shares were allotted to him. Both Mr. Chamberlain and the company had since been advised that the transaction was equivalent to the company selling its shares at a discount, and was therefore obnoxious to the rule of the Court. The company was a very prosperous one, and both they and Mr. Chamberlain were anxions to have the opinion of the Court on the matter, the sole object of the application being to ascertain what the position of the parties was.—Mr. Parker appeared for the Company, and said he was instructed to leave the matter entirely in the hands of the Court.—His Lordship, in giving judgment, said that under the agreement Mr. Chamberlain was to get back the sums he had advanced, either in cash with interest or payment in shares, with equivalent interest in shares for the whole year. It was quite clear, therefore, that the allotment in shares must be for a greater amount than the cash could have been. The shares were therefore issued at a discount. The issue was therefore void, and he made an order removing Mr. Chamberlain's name from the list of contributories of the company in respect of the shares in question.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS.—THURSDAY, March 28.

In Committee of Supply on the vote of the sum of £2,085,616 to defray the salaries and working expenses of the Post Office Telegraph Service, attention was drawn by several members to the abuse of the free service message system by the railway companies, the yearly loss occasioned thereby amounting, it is alleged, to £50,000. The loss upon press messages was also stated to be as much as £200,000 a year, the rates charged for them being altogether inadequate. Mr. SHAW LEFEVRE questioned these figures, but recommended the commutation of the railway companies rights in respect to service messages. Mr. HENNIKER HEATON advocated the statements of Post Office accounts being formed on commercial principles, when the actual revenue would be found to be far better than it appears to be. The introduction of the telephone into every post office, and the adoption of half rates for night messages, were advocated by Mr. Labouchere.

Mr. RAIKES, the Portmaster-General, in replying to these observations, began by explaining the conditions under which the staff of the Submarine Telegraph Company were being taken over into the Post Office Telegraph Service. With regard to the acquisition of the business of that company he was not yet in a position to say what sum was to be paid to the company for plant and goodwill. Though they were on the eve of arriving at a settlement there was yet one nation, at all events, which desired further information before the ratifications of the convention were exchanged. He believed, however, that the committee and the country would be very well satisfied when they came to know the terms on which it was proposed to acquire the cable. Reference had been made by some hon. members to the painful but constantly-recurring subject of the loss entailed on the country by the purchase of the telegraphs. He was able to refer to a very gratifying diminution of that loss in recent years. The deficit of 1887, upon which the select committee commented last year, amounted to nearly half a million, but the accounts for 1888 showed that the deficit was only £6,000 in that year. He hoped that next year the small deficit of the previous year would be turned into a large sum on the other side of the account, and with the prospective profits from the submarine telegraphs now taken over, he trusted the profits would be very largely increased. He thought the figures of the last ten years would be of interest to the Committee. In 1879 the profit upon the working amounted to £280,000; in 1880 it was £296,000; in 1881, £325,000; so that that year the Service was within £1,000 of paying off the interest; the year following, 1882, the profit fell to £213,000; in 1883 it fell to £184,000; and in 1884 there was a deficit of £19,000; in 1885 there was a deficit of £36,000; in 1886, a deficit of £45,000; in 1887, a deficit of £145,000; and last year, 1888, a deficit of £6,000, which was the smallest deficit since they had got on the wrong side of the account. He ventured to believe that next year would see a substantial sum on the other side of the account. The deficit which began in 1884, was coincident with the extension of the telegraph service and the increase of telegraph salaries. Although the sixpenny telegrams had been a very great obstacle for some time, he trusted that obstacle was now surmounted, and that they were now on their way to earn a profit (hear, hear). The deficit of £145,000 in 1887, although due in some degree to the sixpenny telegrams, was in a large degree due to extraordinary expenditure in that year, which would not occur in following years. With regard to the loss on railway messages, he agreed that there had been a great departure from what must have been the original intention of Parliament (hear, hear). He did not think that Parliament could have contemplated that within twenty years the number of those messages would be multiplied tenfold. He should always be glad to extract a *quid pro quo* from the railway companies by enforcing upon them the necessity of giving greater facilities to the public, and he was quite aware that the private Bills coming before Parliament always afforded an opportunity of raising a question of that kind. As to how far the railway companies ought to be made to pay for the facilities given to them by Parliament he would not like to say. With regard to Press messages, they were very well worthy of the consideration of the department and of the public. He must demur to the exact phrase of "loss of £200,000 on Press messages." He thought that was not the most correct way of referring to that part of the question (hear, hear). There was no doubt that if Press messages were sent at the ordinary rates charged to the public the Department would receive £200,000 a year more; but if the same rates were charged to the Press as to the public many of those messages might never be sent at all, and the Department might not receive anything like £200,000 more than at present (hear, hear). That, no doubt, operated largely on the mind of Parliament and of the Ministers who were responsible for that part of the matter, as well as the question of the public convenience and benefit, quite apart from the personal profits of owners of newspapers which might result from cheap telegraphic rates to newspapers (hear, hear). The hon. member for Nottinghamshire made reference to both those questions, and he was extremely grateful to the hon. member for calling attention to the recommendation of the committee that there should be a more strict adherence to commercial principles, and he would be extremely obliged to hon. members if they would assist him in carrying out that recommendation and aid him in resisting applications from those members who applied for every form of uncommercial arrangement for the benefit of the particular localities they represented (hear, hear). He thought it might be sometimes desirable, not so much in the interests of particular localities as in the interests of the general public, to carry out telegraphic works in connection with very distant parts of the Empire which were not strictly remunerative (hear, hear). For instance, in some places in the Highlands of Scotland telegrams are very few, and the offices not likely to be self-supporting, but it was absolutely essential to the living of the people that they should have ready means of telegraphing for salt to salt their fish, upon which the existence of some of the natives might be said to depend. He thought there were a few cases also where the same thing had been done in the North and West of Ireland. He was quite sure the committee would not object to such expenditure, which was the exception from what he thought an excellent general rule (hear, hear). The hon. baronet the member for the Lichfield Division had urged the increase of the number of telegraph offices at railway stations. He found that there was a great objection on the part of railway companies to their servants acting as servants of the Post Office; and it was not desirable to force upon them duties which would interfere with their first duty. It would not, therefore, be easy to increase the number of telegraph stations in this direction. The hon. member for Falkirk had brought forward the question of half-rates for night messages. The present rate at which messages were transmitted was barely remunerative and it would be more than doubtful whether the revenue would stand the strain of messages at half-rates. He would remind the hon. gentleman that the American initial rates were very much higher than ours. Where the rate was 2d. or 2½d. a word it was possible to send at half-rate, but he could not hold out any hope that such a suggestion would be accepted in this country, where the charge was only a halfpenny a word. The tendency of messages was to get shorter and not longer. The average amount per message was now distinctly below 8d. It was 7·9d. And as the tendency was in that direction it was likely to be still further developed as time went on. Before the 6d. telegrams were introduced the average was 1s. 1d. per message. He did not think that the state of the revenue of the Department would justify him in holding out any hope with regard to a cheaper rate of telegraphic transmission. As to the telephonic system, the Courts had declared it to be a part of the Government monopoly in telegraphs. His predecessor (Mr. Fawcett) unfortunately stated in public that steps would not be taken by the Government to enforce the rights which that judgment gave them, and a state of things had thereby been created which required very careful handling so far as the Department was concerned. The patents, however, were likely to lapse very soon, and when they had run out that would be the time to make arrangements, which he trusted would differ in almost every respect from existing arrangements. With regard to telephones being put into post offices, that was subsidiary to the larger question. In some parts of England the telephonic system was under the control of the Government absolutely, and there it was of course comparatively easy to make arrangements such as had been indicated. So long as the telephone companies continued to ply their trade, it was not desirable, he thought, that the Government should commit itself to arrangements which might seem in any way to recognise or establish a vested interest, which he for one could not admit existed. The grievance of the public in this matter ought, no doubt, to be removed as soon as possible, and it should be done upon terms satisfactory to all parties. He congratulated the Committee upon having taken a step which had been looked forward to for many years by all who were anxious to extend our telegraphic system—the step of sanctioning the acquisition of the system of the Submarine Telegraph Company, from which he anticipated the most beneficial results alike for the public and for the Department (cheers).

During the discussion which followed, several hon. members expressed a hope that as soon as sixpenny telegrams were remunerative the free

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addresses, or at all events, a certain number of free words for the addresses, would be restored; and Mr. HENNIKER HEATON complained that the cable companies paid a great deal too little, considering the profits they made, for the rental of the Post Office land lines.

Mr. RAIKES, replying, said that the estimated cost of reverting to free addresses was no less than £400,000 a year, and he would be a bold Minister indeed who would hold out a prospect of incurring such a loss in restoring the old system. His hon. friend wished them to institute a roving commission to ascertain how the Transatlantic and other submarine cable companies transacted their business. He did not see how such an inquiry could be prosecuted, as we had no right to overhaul the books of those companies. Therefore, he could hold out no hope of such an inquiry being instituted. There was no intention on the part of the Government to acquire the telephones by purchase. He might, in conclusion, take this opportunity of referring to the grievous loss the telegraph department had just sustained in the death of Mr. Patey, who was a most competent public servant (hear, hear). His loss was deeply felt and his memory was endeared to all who had had the advantage of serving under him (hear, hear).

COMPANIES' MEETINGS & REPORTS.

Western Counties and South Wales Telephone Company (Limited).

The fourth annual meeting of this Company was held at Bristol on the 27th ult., the Chairman (Mr. Charles Nash) presiding.

The SECRETARY (Mr. H. F. Lewis) having read the notice convening the meeting.

The CHAIRMAN said that it was customary to take the reports and accounts as read, and he would move that they be approved and adopted. The Directors met the shareholders at a somewhat earlier date that year than last, and upon the whole he hoped they would agree with him that it was a satisfactory report that they were now able to put before them. There were some results of the working during the last three years that he would put very briefly before them. Their gross revenue in 1886 was 27¼ per cent. upon the capital expenditure, in 1887 it was 27¾, and in 1888 it had risen to 28½ per cent. Upon the other hand, the working expenses had decreased during those three years from about 32 per cent. of the gross revenue in 1886 to less than 26 per cent. in 1888. Looking at the net revenue, that yielded a percentage upon the capital outlay of 5½ per cent. in 1886, 7 per cent. in 1887, and 8 per cent. in 1888, the figures being £3,184 in 1886, £6,007 in 1887, and £9,059 in 1888. From 1886 to 1888 the subscribers had very nearly doubled. They were 1,318 in 1886 and 2,610 last year, and the wire mileage had increased during that time very nearly threefold. Then he might add that, with scarcely an exception, at every one of the exchanges there had been a considerable increase in business. The rate of increase no doubt varied much. At Newport it had been more than doubled, at Bath and Exeter it had increased more than 50 per cent., at Cardiff 40 per cent., at Plymouth 30 per cent., at Portsmouth 25 per cent., Bournemouth and Torquay 20 per cent. All that had not been accomplished without very close attention to details, and the Directors had given a great deal of time and thought, and had exercised great supervision over the general working as far as they possibly could. He need not say that the result was largely and principally due to the energy and ability of the secretary, Mr. Lewis. His work, he could assure them, had not been a light one, to keep in view the working of thirty-four exchanges, extending from Shrewsbury in the north to Plymouth in the south, and westward from Portsmouth to Swansea and Llanelly. He did not think that it was necessary to say much about the future, but he might say this much, that their large district was very far from being covered; there was still a great deal of ground that they hoped might be profitably occupied, and those towns where business was already carried on admitted of an extension of business. Then again there was the trunk connection that they were looking forward to, to London, Birmingham, and other places in the north, which might have the effect of adding considerably to their local subscribers as well as bringing a considerable number of messages upon the trunks themselves, and all that, he thought, led them to the conclusion that there was room for considerable further development, and he could only say that it was the aim of the board to foster and develop it as far as they could.

Mr. MARK WHITWILL (Deputy-Chairman) seconded the resolution, and said that they would see that the business was growing fast, and it would be further developed as fast as they thought prudent. They looked forward with hope and confidence to the future.

The motion was carried.

The CHAIRMAN then moved—

"*That a dividend of 6 per cent. be paid to the preference shareholders, and that the amounts already paid by the Directors on account of such dividend be approved and confirmed.*"

Mr. T. POLE seconded the motion, which was adopted.

The CHAIRMAN then moved—

"*That a dividend at the rate of ½ per cent. per annum be paid upon the ordinary shares, payable on the 30th inst.*"

Mr. H. FEDDEN seconded the resolution, which was also carried.

The CHAIRMAN said that Mr. Mark Whitwill retired by rotation from the directorate, and was eligible for re-election.

Mr. A. POLE proposed Mr. Whitwill's re-election, which was seconded by Mr. STUCKEY, and carried.

Mr. WHITWILL having returned thanks,

The CHAIRMAN mentioned that Commander Douglas Forsyth, R.N., one of the Directors, felt that, owing to the distance he lived from Bristol, he was unable to continue upon the directorate. He thought they ought not to allow Commander Forsyth to retire without an expression of thanks for his past services.

Commander FORSYTH suitably acknowledged the compliment, and spoke of the valuable assistance he had always received from Mr. Lewis and the staff generally.

The CHAIRMAN proposed that £200 be placed to the special reserve fund, making that fund amount to £1,200.

Commander FORSYTH seconded the motion, which was carried.

Mr. MARK WHITWILL proposed the re-election of the auditors, Messrs. Hudson Smith, Briggs and Co.

Mr. H. FEDDEN seconded the motion, which was carried.

The CHAIRMAN said that, owing to the work of the auditors having increased, it was proposed to increase their remuneration to £99. 15s.

Mr. T. POLE seconded the resolution, which was agreed to.

The CHAIRMAN said that they were all aware that there had been some most calamitous floods in Bristol, and there had been large subscriptions given, not only by individuals and firms but by public companies, and he did not think that their telephone company should be left out. He did not know how the members would regard it, but the suggestion of the Directors was that they should contribute twenty guineas to the relief fund, to be paid out of the balance that was carried over to last year's accounts.

Mr. REED proposed that they should give twenty guineas.

Mr. WHITE seconded the motion, which was adopted.

Mr. J. INSKIP proposed that the remuneration of the Directors should be increased from £400 to £500.

This was seconded by Mr. REED, and adopted.

Liverpool Electric Supply Company (Limited).

The sixth annual meeting of the shareholders of this Company was held in the Law Association-rooms, Liverpool, on Tuesday, March 26th, Mr. A. H. Holmes presiding.

In presenting their sixth annual statement, the Directors reported a considerable extension of the Company's business during the past twelve months, and the accounts showed the amount of net profit available for dividend, including the balance brought forward from 1887, to be £1,788. 0s. 3d. Out of this sum the Directors recommended the payment of a dividend of 3 per cent., absorbing £1,067. The capital expenditure during the year on land, buildings and plant, including a proportionate charge for general expenses, amounted to £20,919. 16s. 4d. The greater part of these additions could not be brought into remunerative working condition during the year, but the effect on the earnings of the Company might be judged from the fact that the amount received for the supply of electricity during January, 1889, exceeded by about 20 per cent. the average monthly receipts for last November and December, and amounted to nearly four times the revenue derived from this source in January, 1888. In the month of June the Board of Trade issued to the Company a license authorising them to supply electricity by means of underground mains throughout certain portions of the city, and the Directors had opened negotiations with the local authority with the view of obtaining for the Company a Provisional Order, so as to secure the advantages afforded by the amended Electric Lighting Act of 1888. They confidently hoped that in the interests of the public as well as the Company these negotiations might be brought to a successful issue. The total number of incandescent lamps now in connection with the Company's system is three times greater than at the commencement of last year. The Directors have secured a suitable site in Highfield-street for the extension of the Company's most important station. Negotiations had also been completed for the purchase of a very favourable site for a central station for the Lime-street and residential districts of the city. The Company had in hand numerous orders for electric fittings, and had secured the contract for the electric lighting of two new steamers now building for the White Star line.

The CHAIRMAN, in proposing the adoption of the report, said the Company were proceeding with the underground mains as they were required by customers. Bold-street had been omitted from the area of license, but the Company were in negotiations with the Watch Committee in order to have the supply extended to that thoroughfare, and also to take advantage of the new Act of 1888. In their negotiations with the Watch Committee he had no doubt they would succeed. The position of the Company as a dividend-paying concern they knew. The initial expenditure was necessarily very large, but their receipts were increasing, and the Directors had written off a large sum for depreciation. To provide for the expenditure on underground mains and three new stations they would have to call up the remainder of the share capital.

Sir JAMES PICTON seconded the motion, and the report was adopted unanimously.

Messrs. A. H. Holmes and Mr. J. S. H. Banner were re-elected directors, and Mr. W. Jackson auditor.

Edmundson's (Limited).

The statutory meeting of this Company was held on their premises, 19, Great George-street, Westminster, on the 28th inst.

Mr. John R. Wigham, J.P., Chairman of the Company, presided.

The CHAIRMAN congratulated the shareholders on the satisfactory position of the Company. He stated that a larger amount of trade had

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been done since the acquisition of the business by the Company, dating from July last, than in the whole of any year during which the trade had been carried on by their predecessors, and that the prospects of the Company, in view of the advances that are being made in electric lighting, are exceedingly encouraging. He also mentioned that the shares had been all taken up within a few days after the issue of the prospectus, and that they are held exclusively by the customers and the Directors, many of the former being amongst the largest consumers of electric light in this country.

The out-going Directors were all re-elected.

The Eastern Extension, Australasia and China Telegraph Company (Limited).

Report and accounts of the Directors for the half-year ended 31st December, 1888, to be submitted to the thirty-first ordinary general meeting, to be held at Winchester House, on Wednesday, the 10th inst., at two o'clock:—

2. The gross receipts, including Government subsidies, have amounted during that period to £238,854. 14s. 4d., against £232,660. 0s. 11d. for the corresponding half-year of 1887.

3. The working and other expenses, including £23.883. 2s. 7d. for cost of repairs to cables, and expenses of ships, absorb £71,519. 7s 4d. against £69,570. 16s. 5d. for the corresponding period of 1887, leaving a balance of £167,335. 7s. 0d. From this is deducted £3,049. 15s. 0d. for income tax, £41,585 for interest on debentures and contributions to sinking funds, and £4,492. 7s. 11d. for rebuilding staff quarters at Cape St. James, leaving £118,198. 4s. 1d. as the net profit for the half-year, which, with £47,903 4s. 1d. brought forward from the previous half-year, shows an available balance of £166,101. 8s. 2d.

4. One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 3s. per share, or 1¼ per cent., making a total distribution of 6¼ per cent., for the year 1888. The balance of £66,101. 8s. 2d. has been carried to the general reserve fund, which, after being credited with the interest on investments received during the half-year, and debited with the cost of the partial renewals of the Java-Australian cables off the Lombok Straits, amounting to £18,986. 19s. 5d., now stands at £690,454. 18s. 4d.

5. In pursuance of the conditions upon which the issue was made 119 of the Company's Five per Cent. Debentures of 1880 were drawn by lot on the 11th ultimo for payment at par on the 1st May proximo.

291 of the Company's Five per Cent. Australian Government Subsidy Debentures were also drawn on the 1st instant for payment at par on the 1st July next.

(Numbers of the drawn debentures will be found in our advertisement pages.)

6. The Company's maintenance ships have been employed on various repairs during the half-year under review, as shown in abstract C, but no interruptions of a serious nature have taken place beyond those on the Australian section referred to in the last report, and subsequently for a few days whilst carrying out the renewals off the Lombok Straits. All the Company's cables are now in good working order.

7. Since the close of the half-year telegraphic communication with the Australasian Colonies has been greatly strengthened by the extension of the Company's system from Java to Western Australia. This extension, as explained in the last report, gives the Colonies a third cable to Java, and brings into use the Western Australian land lines as an alternative system to the South Australian overland line, thus minimising the risk of interruptions in the future.

8. Your Directors have the pleasure to report that an agreement has been recently concluded with the Government of Tasmania, by which the Company's exclusive privilege of telegraphic communication between Tasmania and Victoria, which by effluxion of time would expire next year, has been extended for a further term of twenty years. The subsidy of £4,200 per annum, payable to the Company by the Government, will be continued for the same period.

9. In accordance with the Articles of Association, Sir James Anderson and Francis Augustus Bevan, Esq., retire by rotation, and, being eligible, offer themselves for re-election.

1 . The auditor, Mr. Henry Dever, retires, and offers himself for re-election. The auditors, Messrs. Quilter, Welton and Co., also retire, and offer themselves for re-election under their new style of Welton, Jones and Co., adopted since the death of Mr. Quilter.

The Oriental Telephone Company (Limited).

Report of the Directors for the year ended 31st December, 1888, to be presented at the ninth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, London, E.C., on Tuesday the 16th inst., at one o'clock.

The revenue account shows a balance at credit of £6,651. 12s. 8d., which has been transferred to profit and loss. Including the sum of £3,602. 16s 1d. brought forward from the previous year, the amount available for disposal is £10,254. 8s 9d., which the Directors recommend should be dealt with as follows: To place £2,500 to a reserve fund; to apply £3,000 in final extinction of preliminary expenses; to write off £341. 4s 8d for depreciation of stores and balance cost of reconstruction of the Rangoon Exchange, and to pay a dividend of 3 per cent, free of income-tax, on the paid-up capital of the Company, other than the vendors' shares, carrying forward £685. 18s. 11d.

The Directors consider that until some satisfactory arrangement has been come to with the holders of the vendors' shares, the soundest policy is to pay small dividends and to build up a reserve fund sufficient to meet whatever contingencies may happen.

The amounts received and to be received from the Indian companies for dividends for the past year on the shares held by this Company, and which have been brought into the revenue account, include £150 belonging to 1887, and a small surplus arising on final settlement of the guarantee to the Bengal Telephone Company.

The returns from the Indian companies show a moderate improvement, but the business in India generally is heavily weighted by Government and local taxes; and the continued restrictive policy of the Indian Telegraph Department acts detrimentally. An alteration in the management of the Bengal Company, carried out by your Directors, has effected considerable saving in the working expenses of that Company.

The Telephone Company of Egypt maintains its revenue, and has declared a dividend of 6 per cent. for the past year, free of income tax, carrying forward a sum of £1,069 14s. 11d. The Directors of that Company have placed £5,000 of debentures in Egypt, bearing interest at 6 per cent., and were thereby enabled to pay off the loan due to this Company.

At Rangoon and Singapore the branches are making satisfactory progress; but at Madras, Colombo and Mauritius the revenues remain stationary.

The China and Japan Company's accounts for the past year exhibit a small surplus after paying debenture interest.

The question of the Company's rights in the Australasian Colonies has been settled by an agreement being come to with the Western Electric Company of Chicago, whereby that Company has undertaken to pay certain royalties. A payment has already been received in respect of these royalties, which has been applied in part reduction of the outlay incurred.

The retiring Directors are Mr. Henry Grewing and Mr. Thomas Lloyd, both of whom being eligible offer themselves for re-election. Messrs. Deloitte, Dever, Griffiths and Co., the auditors of the Company, retire, but offer themselves for re-election.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
PHOSPHOR BRONZE
VULCAN PHOSPHOR BRONZE COMPANY
DURO METAL
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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Electrical Power Storage Company (Limited).

Report of the Directors, to be presented to the shareholders at the eighth ordinary general meeting, to be held at Winchester House, Old Broad-street, E.C., on Wednesday, the 10th inst., at 12:30 p.m.

The gross profit for the year is £13,273. 15s. 3d., which includes all royalties and receipts, the bulk of this profit being derived from the manufacture of storage batteries and special apparatus in connection therewith. The expenditure for the year, including debenture and other interest, &c., is £11,709. 3s. 8d., and the balance added to the amount standing to the credit of profit and loss, makes the sum of £8,372. 13s. 6d., out of which the Directors would recommend a dividend were it not that the increasing volume of business demands a larger working capital, and the best method of securing this has been, and is, a subject of anxious consideration by the Directors.

During the year under review there was a considerable increase in the Company's business, while, as compared with the corresponding period of the year 1888, the orders received this year up to date have already nearly doubled. To meet this rapid growth of business it has been necessary to make a considerable outlay on the Millwall Works, and to increase the staff. This additional outlay amounts to £1,827. 3s. 6d.

The Directors are glad to state that the Company is not engaged in any litigation.

Among the many new electric light installations employing storage batteries may be mentioned the Lyric Theatre, where a 1,000 sixteen candle-power E.P.S. battery is erected; the London Joint-Stock Bank, the private residences of Sir Henry Meux, Bart.; J. Fletcher Moulton, Esq., Q.C.; Alfred de Rothschild, Esq.; Dr. John Hopkinson, F.R.S., and the Royal Arsenal, Woolwich.

The new form of battery, known as the "1888" type, continues to give satisfaction.

A number of scientific and technical institutions have adopted accumulators, viz., the Central Guilds of London Institute, Millard Laboratory, Oxford; Cavendish Laboratory, Cambridge; University College of Wales, Cardiff; Heriot-Watt College, Edinburgh; Queen's College, Cork; and the University of Japan, Tokio.

A gold medal was awarded the Company at the Brussels Exhibition for their exhibit of storage batteries and accessory apparatus.

Central station lighting, which the Directors have regarded as ultimately the main source for the use on a commercial scale of storage batteries, is at last beginning to attract the serious attention of the public, and it is hoped that many of the applications for provisional orders now before the Board of Trade may be granted and confirmed by Parliament during the current year, as, until that result is attained, the full effect of the alteration of the law by the Electric Lighting Amendment Act of 1888 cannot be felt. The only Company in the metropolis which possesses the requisite Parliamentary powers is the Chelsea Electricity Supply Company, under 50 Vic., cap. 18, with which Company a contract has been made for the supply of a large accumulator battery for its central station and sub-station; the Chelsea Company will work its central station on the distribution system of the E.P.S. Company, and will supply light during the present month. Batteries have also been furnished for central stations in various parts of the kingdom.

Accumulators for train lighting have been in demand. Extensions have been made to the lighting plant of the London, Brighton, and South Coast and Great Northern Railways, and batteries for this purpose have also been furnished to the Midland, London and North Western, and Taff Vale Railways, and South Western Railway of Russia. For ship and yacht lighting a new type of accumulator has been designed, and has been supplied to the British navy, the Italian and Danish navies, and to yachts, among which may be mentioned the "Mohican," "Wanderer," and "Torfrida." The lighting of forty omnibuses of the London General Omnibus Company is carried out by means of E.P.S. accumulators.

In surgical batteries a new use for accumulators has been found, and a portable type battery has been made from which current is supplied to cauteries, induction coils, motors, and lamps; and to give special facility for recharging in London, Messrs. Coxeter and Sons, the surgical instrument makers, have established a charging station in Grafton-street, W.C. For the propulsion of electric tramcars a large order has been received from the Electric Traction Company for storage batteries for six cars for working on the Barking line. An interesting experiment has also been made by Mr. Sandwell in propelling tramcars by batteries carried on a separate truck or bogie.

In electric launches, worked from storage batteries, progress has been made, as E.P.S. batteries are used in the "Maldon" and the "Viscountess Bury," the latter a boat 65ft. long by 10ft. beam. E.P.S. accumulators are also employed by Mr. Radcliffe Ward in his method of propelling vehicles on ordinary roads by electricity. Throughout Europe the advantages of the use of storage batteries are gradually being realised, but several causes have tended to delay their general adoption. This year the Directors hope the amount of royalties will be substantially increased, as the various companies and firms with whom arrangements have been made to manufacture E.P.S. batteries under royalty have completed the erection of their factories. These are to supply the batteries in Germany, Austria, Hungary, France, Russia, Finland, and the Scandinavian countries.

The Electrical Accumulator Company of New York is pushing the business vigorously in all directions on the American Continent, and a pamphlet published by that Company, showing how successful it has been in establishing its patent rights in the United States, will be read by the shareholders with much interest.

The retiring Directors are Sir Daniel Cooper, Bart., and J. Irving Courtenay, Esq., who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever and Co., also offer themselves for re-election.

NEW COMPANIES REGISTERED.

THE HALIFAX MUTUAL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Registered by C. Doubble, 14, Serjeant's-inn, Temple, E.C., with a capital of £20,000 in £5 shares. Objects, to generally carry on the business of electrical engineers, manufacturers, contractors and electric lighting, and to acquire concessions from or with Governments, municipal or other authorities, for the supply and produce of same. The number of directors shall not be less than three nor more than seven. Remuneration to be determined in general meeting.

THE NEW PORTABLE ELECTRIC LAMP AND POWER SYNDICATE COMPANY (LIMITED).—This company have resolved to wind up, and Mr. James A. Hays and Mr. Benjamin Nicholson are appointed joint liquidators.

PLANET ELECTRICAL ENGINEERING COMPANY.—This company was registered on the 26th inst., with a capital of £20,000 in £5 shares, to carry on the business of an electric light company in all branches. One of the original subscribers is Mr. A. L. Shephard, of 2, Victoria-mansions.

CITY NOTES, &c.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of this Company, held on March 29, it was resolved to declare an interim dividend for the quarter ending March 31, 1889, of 12s. 6d. per cent. on the Ordinary Stock and 25s. per cent. on the Preferred Stock, less income tax, payable on May 1 to the stockholders registered on the books of the Company on April 1, 1889.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of March was 5,992, estimated to produce £4,500, against 4,919 messages, producing £3,835 in the corresponding month of last year. The traffic receipts for the month of December, estimated at £3,500, realised £3,508.

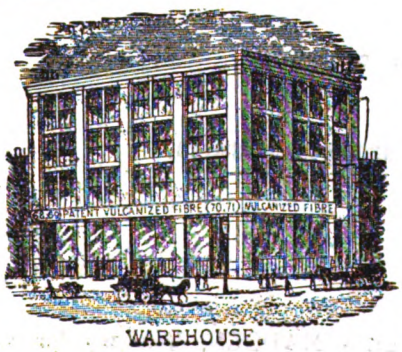
DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of March amounted to £2,129, as compared with £1,900 last year.

TELEPHONE COMPANY OF AUSTRIA.—The directors have declared the usual half yearly dividend to 31st March on the preference shares, at the rate of 6 per cent. per annum.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).—The traffic receipts of this company for the month ended 31st March, 1889, amounted to £5,950.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts of this company for the half-month ended March 31st, 1889, were £3,714, against £3,714 for the corresponding period last year.

THE NON-CONDUCTOR OF ELECTRICITY.

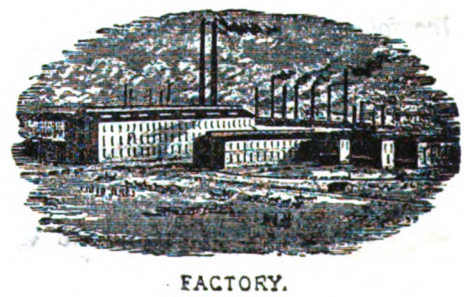


WAREHOUSE.

VULCANISED FIBRE,
PATENTED.

This new material is supplied in two qualities, Flexible and Hard.
The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.
It makes the best Hot and Cold Water Packings, and for Axle Washers of all kinds it is unequalled.
The HARD is a substitute for Metals, Hard Wood, Ivory, Vulcanite, Ebonite, &c., and is a good Insulator.
Sold in sheets, 5ft. 6in. by 3ft. 6in., varying in thickness from 1-50in. to 1in.

FLEXIBLE, 2/- per lb.; HARD, 2/3 per lb.


FACTORY.

MOSSES & MITCHELL, 70 Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Price, Wednesday, April 3, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending April 3, 1889.	
							Highest.	Lowest.
£			**TELEGRAPHS.**		£ s. d.			
1,770,360	Stock	15/0	Anglo-American	50 51	3 18 5	Jan., Apr., July, Oct.	51¼	50¼
2,614,820	Stock	30/0	Do. Preferred	84 85	4 14 2	,, ,,	86	82⅝
2,614,820	Stock	...	Do. Deferred	16¾ 17¼	...	February	17⅛	16½
130,000	£10	3/0	Brazilian Submarine xd	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13⅜	...
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
75,000	£100	5%	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 14⅝	6 2 0	February and August	14½	...
6,000	10	10/0	Do. Preference 10%	18⅝ 19⅛	5 2 7	,, ,,	...	...
12,931	5	1/7½	Direct Spanish (£4 paid) xd	3½ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10% xd	8⅛ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	9⅝ 10⅛	3 19 0	Jan., Apr., July, Oct.	10⅛	9⅝
380,000	10	2/6	Eastern	13 13½	4 10 7	,, ,,	13⅜	12 15/16
70,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	15	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	107	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	106 109	4 11 9	February & August	108	...
250,000	10	2/6	Eastern Extension	13 13¼	4 18 1	Jan., Apr., July, Oct.	13 3/16	13
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	102⅓	...
179,177	10	1/3	Globe Telegraph and Trust	7¼ 7⅜	4 16 8	Jan., Apr., July, Oct.	7⅛	7 1/16
178,992	10	3/0	Do. 6 per Cent. Preference	14½ 14⅝	4 2 9	,, ,,	14⅝	14½
150,000	10	5/0	Great Northern	14⅝ 15¼	4 18 4	Jan., July, and April	15¼	14⅞
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	7¼ 7⅝	5 3 2	April and October	...	...
15,609	10	3/0	West African Telegraph	7 8	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	...	100
30,000	10	6/0	West Coast of America	9¾ 10½	4 17 7	January and July	...	9¾
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅜ 1¾	...	...	1 1/16	1 1/16
34,563	10	12/0*	Do. 1st Preference 6%	10⅜ 11½	...	April and October	11	...
4,669	10	†	Do. 6 per Cent. 2nd Preference	11⅜ 12½	...	...	12	11⅜
45,181	15	6/0	Western Brazilian	12½ 13	5 15 3	March & September	13¼	12⅝
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	4⅛d.	Consolidated Telephone and Maintenance	1/16 1/16	...	Yearly	...	...
220,000	£1	3%	Oriental (11s. paid)	⅜ ½	3 6 1	...	...	...
80,000	5	5/0	United	15⅜ 16	4 13 9	June and December	15⅞	15 5/8
55,000	5	...	United River Plate	5⅝ 5⅞	...	January and July	5⅜	5⅛
			ELECTRIC LIGHT.					
23,003	5	...	Anglo-American Brush (£4 paid)	3⅛ 3¾	...	...	...	...
23,692	5	nil.	Do. (fully paid)	4⅛ 4½	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2⅝ 2⅞	...	...	2½	2⅜
312,000	¼	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42⅛	41½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works xd	17½ 18½	5 8 1	February & August	18⅜	17⅝

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.
Johnson & Phillips.
J. G. Statter & Co., Limited.

MANVILLE & MADGEN, *Managing Directors.*

3, Prince's Mansions, Victoria Street, Westminster.

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 569.—Vol. XXII. FRIDAY, APRIL 12, 1889. Price Fourpence.

NOTES.

The progress made during the week by the Board of Trade Inquiry is, we suppose, as great as could reasonably be expected. The evidence on behalf of the "London" and the "Metropolitan" Companies has been completed, and Mr. Moulton (in a speech of marked ability, full of keen satire and accurate science) has opened the case on behalf of the Chelsea Electricity Supply Company. In so doing, he intimated that he put himself forward as the champion of all the companies who offered to furnish a direct current supply. The case on behalf of the storage battery could scarcely have been better put, although, of course, no new argument was introduced.

A very considerable amount of time is wasted at the Inquiry by the attempts of unscientific counsel to extract technical information from directors, managers, and other unscientific witnesses; but the representatives of the Vestries and other local authorities are eager to pick up all the knowledge they can. There is a general impression that The London Electric Supply Company intends to pump the electric fluid from Deptford through Mr. Ferranti's tubular mains at an enormous pressure, which, but for the pedantry of the scientific gentlemen, might be expressed in pounds per square inch. It is obvious that the electric fluid will squirt out at the joints if these are not carefully made, and, therefore, the road surveyors are most pertinacious in their inquiries on this point.

After prodding the insulation with penknives and thumb-nails some of the more practical vestrymen think that, considering the present prices of copper and the large capital of the company, it would be doing things in a more handsome style if the mains were made of solid copper tubes.

It is rather a pity that, as the Inquiry did not sit on Tuesday, Thursday, and Friday this week, there were not a few lectures on elementary electricity delivered on those days for the instruction of some of the people engaged.

The Committee of the Electrical Section of the Chamber of Commerce has lost no time in taking action upon the suggestion of the Chairman as to the appointment of a permanent official, and the arrangement has been carried out on the lines indicated in our last issue. A special meeting of the Committee was held on Saturday last, when, as we are happy to announce, the appointment was offered to, and accepted by, Mr. A. P. Trotter. As to Mr. Trotter's many qualifications for the position we need not stay to speak; we feel sure that the appointment is one which will be received with universal satisfaction, and which the Section will have no cause to regret. We may add that Mr. Trotter's business address is No. 2, Victoria-mansions, Westminster (Telephone No. 3086). The exact nature and extent of the duties attaching to the office have not yet been clearly defined, but it is quite evident that Mr. Trotter will find plenty of work immediately to hand in looking after the general interests of the Section.

Our readers will be glad to learn that the Board of Trade has signified its willingness to receive a deputation from the Electrical Section on the overhead wire question. It has, however, been considered desirable to postpone the matter until the conclusion of the present inquiry.

Perhaps the most interesting point in Prof. Forbes' report to the Electric Lighting Committee of the Paddington Vestry is contained in the proposal to obtain the whole of the fuel for maintaining 15,000 50-watt incandescent and 400 arc lamps from the parish dust-bins. Prof. Forbes has himself designed a furnace for the consumption of refuse, for which he expects to obtain a horse-power for about 15lb. of fuel of this class per hour. It is also suggested that the clinkers be ground up to make paving stones, as is already done at Southampton. The arc lighting is to extend over every court and alley of the district, and is to cost in the end £9,044 per annum, or about £4,000 more than the present gas lighting. Prof. Forbes further estimates that the Vestry will be able to supply the private consumers at 3s. 6½d. per Board of Trade unit—or 4¼d. in the old measure. The estimates are not given in sufficient detail to allow of much criticism. We notice, however, that as many as 50 lamps are allowed on the average for each consumer, and, what is more striking, the arc light cables are to be purchased and laid (not including the conduit) for £100 per mile. We are glad to see that the estimated revenue is based upon the reasonable figure of 700 lamp-hours per lamp per annum.

We publish this week a series of Memoranda by Dr. Oliver Lodge in connection with the proposal to establish experimental lightning conductors at certain telegraph stations abroad where thunder-storms are periodic phenomena. We have already stated that the Eastern Telegraph Company has expressed its

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willingness to lend assistance, and we have also received letters from members of that Company's staff who are anxious to take part in the observations. We have, therefore, every reason to anticipate that results of considerable scientific and practical importance will eventually be achieved. As the observations will be carried out by duly qualified electricians, there should be no reason to fear any mishap to those concerned. It is sufficient to remark that the arrangements proposed will be as far as possible self-recording in character, and we need hardly say that in every case the observer will be careful to give the experimental conductor a wide berth during a thunderstorm.

On this subject we may remark that in the Report of the Lightning Rod Conference (1882), p. 2, we read:—"A man may with perfect impunity clasp a copper rod an inch in diameter, the bottom of which is well connected with moist earth, while the top of it receives a violent flash of lightning." Now this can only have been a pious opinion on the part of the members of the Conference, and we have now good reason to believe that the experiment would be foolhardy in the extreme. On the same page we are told that if the conductor be of sufficient height, of ample dimensions, and well connected to earth, it "might even be surrounded by gunpowder in the heaviest storm without risk or danger." This assertion was made, we need hardly say, before the discovery of the "side-flash," but it was perhaps a little unscientific on the part of the Conference to make such dogmatic assertions for which direct evidence was certainly wanting. In the light of present knowledge we can only conclude that either event might happen a dozen times with impunity, and on the thirteenth a catastrophe might arise. The fact, however, of such statements remaining on record as the authoritative expression of the opinion of the leading electricians of the day emphasises the need of thrashing out the whole subject with the least possible delay.

In reference to the progress made with negotiations for the amalgamation of the three leading Telephone Companies, which we recently announced, the following is the text of a circular issued by the Lancashire and Cheshire Telephonic Exchange Company:—

"Manchester, 5th April, 1889.

"For the past eighteen months your Board of Directors have been in frequent consultation with the United Telephone Company and the National Telephone Company with a view to amalgamation. The details of the amalgamation have not been finally settled, but it has been provisionally arranged that the basis of such amalgamation shall be the market value of the respective shares, estimated as follows:—United Company, £15; National Company, £6; and £1. 11s. 6d. as the value of each £1 share in the Lancashire and Cheshire Company. When the necessary formalities are completed, a circular will be forwarded inviting you to attend an extraordinary general meeting of shareholders to consider and (if thought fit) to approve of the draft agreement which will then be submitted.

"Joseph Thompson, Chairman."

We announced a fortnight ago that the United Telephone Company had commenced an action against the New Telephone Company. We may add that a separate action has been entered against each Director individually. We have reason, however, to believe that the case will be settled out of Court.

A statement has appeared in the daily papers to the effect that M. Courlon (Chef des Postes et Télégraphes) had "ordered a series of experiments to be undertaken with a view of establishing telephonic communication between London and Paris." This announcement is obviously incorrect as it stands. It is true that the question of the desirability of establishing such communication has been taken into consideration by the two administrations concerned, but nothing has yet been decided, pending reports from the technical officers. A special cable would of course be required.

In saying last week that nobody had protested against the new rates to the Continent we reckoned without our Henniker Heaton. That eminent authority on cable charges had written his protest, but it did not appear in *The Times* until the morning we published our editorial note. Even Mr. Henniker Heaton, however, has failed to spot the particular point on which we commented. What he complains of is that the word rate to France has been reduced only to 2d. instead of to 1d. as it ought to have been. We fail to see why it ought not to have come down to a halfpenny on his showing; for his argument is based on the absurdity of charging 2d. across the Straits of Dover while charging only ½d. across the Irish Channel. Perhaps when Ireland gets Home Rule that anomaly may be rectified. But, meanwhile, Ireland enjoys a halfpenny rate with England and Scotland because she is part of the United Kingdom, which is content to pay a trifle more than it otherwise need pay in order to keep up unity and uniformity of things. That higher rates prevail beyond national frontiers may be absurd, but they are not peculiar to this country; and if it were not for the fact that Mr. Henniker Heaton would be nobody if he had not a grievance against the British Post Office, we should be unable to understand why he does not "go for" the French, German, and Belgian Governments, who all alike maintain higher rates between each other, and are responsible for the still higher rates through these international cables.

But Mr. Henniker Heaton was mildness itself compared to *The Times* next day. According to that journal, Mr. Raikes has betrayed the British Parliament into sanctioning an agreement without that full discussion of its merits which of course would have persuaded the French Government to reverse the decision it had long ago come to with the several Governments interested. So argues *The Times*; but if nothing better than its own arguments could have been discovered in Parliament they would have convinced not even the British Government, much less either the French, German or Belgian. Why, asks *The Times*, seeing that Anglo-Continental letters are charged only the combined inland postage of the two countries, and nothing for the steam packet—why should telegrams be taxed an extra penny for the intervening cable? The question is self-destructive, since it might be asked of any cable connecting Great Britain with her colonies or with the United States. But as regards the particular case in question, the one practical answer which has probably prevailed is this: Postage is profitable and can afford a margin for unremunerative expenditure. The Telegraphs on the Continent as well as in England are

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worked at a loss. When the inland tariffs were fixed no account was taken of a large outlay on present and future international cables; and by foregoing any return upon this extra capital the Governments would simply increase the existing losses, and probably perpetuate them; whereas by charging for the cable service now these losses may be recovered and the cables ultimately freed.

In the sad accident which occurred at Deptford on Tuesday morning it was only by the narrowest margin that both Major Marindin and Mr. Ferranti escaped from being numbered amongst the victims. At the moment when the steam-pipe burst Major Marindin had just passed the spot. Had the Inspector been accompanied by the Directors of the Company, as was at first proposed, we should in all probability have had to lament a distressing catastrophe. As it is, one poor fellow was killed on the spot by falling from a staging, though we are pleased to learn that the three men who were scalded are all doing well.

Our New York letter contains this week a detailed account of the important decision just rendered in the United States Courts in the action brought by the Electrical Accumulator Company against the Julien Electric Company, who were alleged to have infringed the patents of Faure and Swan for the construction of secondary batteries. In the end it will be seen that the Swan patents have been declared invalid, and only one claim in Faure's patent has been sustained. Our correspondent is of opinion that this decision practically leaves the Brush patent master of the field. He anticipates a great extension in the use of secondary batteries in the States at an early period.

We believe that the statement published by a contemporary to the effect that the Edison-Swan Company are about to commence an action against the makers of the Sunbeam lamp for infringement is not quite correct. Although we are without authoritative information, we believe it will be found that it is the Cheesbrough, and not the Edison patent, which is in question, and, further, that the makers of the Sunbeam lamp deny that the filaments are flashed. We also have some reason to believe that the matter is in a fair way of settlement out of Court.

St. Martin's-in-the-Fields Vestry.—This Vestry has decided to have the Vestry Hall lighted by electricity.

Italian Telegraph Department.—The King of Italy has recently signed a decree creating a Ministry of Posts and Telegraphs.

Saragossa.—A central station on the alternating current transformer system will shortly be in operation at Saragossa, the dynamos being driven by water-power.

Chelsea Electrical Supply Company.—This company commenced the supply of current yesterday (Thursday) evening, from which period the supply will be continuously maintained,

Telephones in Russia.—A *Standard* telegram mentions that a Franco-Russian Company has been formed to establish telephonic communication between Berlin, Moscow, Warsaw, and St. Petersburg.

The Brooks' Underground Cable System.—We learn that Messrs. Johnson and Phillips have been appointed sole licensees and manufacturers in the United Kingdom of Brooks' underground wires method of laying mains.

The Royal Society.—The Bakerian Lecture was appointed to be delivered yesterday (Thursday) afternoon by Prof. Thorpe, F.R.S., and Prof. Rücker, F.R.S., on a Magnetic Survey of the British Isles for the Epoch January 1, 1886.

The Electric Light at University College.—The library of University College (London), which has for some time past been closed of an evening owing to the damage done to the books by the gas, will we hear be wholly lighted by electricity.

Lurgan.—At a recent meeting of the Lurgan Town Commissioners a committee was appointed "to confer with the gentleman who had introduced electric lighting in Ballymena, with a view to ascertaining the probable cost of electric lighting in Lurgan."

Milan.—A new central telephone exchange will shortly be opened in the Galerie Victor Emmanuel at Milan. The exchange will be capable of accommodating 3,000 subscribers. The entire service will now be concentrated in this building, and several switch rooms hitherto in use will be closed.

A New Post Office Submarine Cable.—The Telegraph Construction and Maintenance Company has just manufactured for the Post Office one of the largest shore end cables which has hitherto been constructed. The cable is a 4-core one, and is very heavily armoured, weighing nearly 28 tons per mile.

Paris.—M.M. Tschierer and Fuchs, of Puteaux, have recently established a central station at 18, Rue Beaubourg, for the distribution of power by electricity. The plant, says the *Bulletin de l'Electricité*, comprises a 110 horse-power horizontal Corliss engine and two Gramme machines, giving 370 amperes and 110 volts.

Harleston.—Messrs. Knights and Stacey have received an order to fit the extensive mills and maltings of Messrs. Edwards and Co. with the electric light. This firm are the agents for the Eastern counties for Spiel's petroleum engine, and have recently given several demonstrations of its suitability to dynamo driving.

Telephonic Directory for the Aberdeen District.—In addition to the usual alphabetical list of subscribers, this directory contains a carefully compiled list of subscribers arranged under their professional and business headings. The lists are accompanied by a map showing the existing and projected system of the National Telephone Company in Central Scotland.

Coast Telegraphs.—In reply to Mr. Johnston, Sir M. Hicks-Beach said, in the House of Commons on Tuesday evening, that the question of telegraphic communication between lighthouses, coastguard stations, and lifeboat stations round the coast was a matter for the consideration of the Post Office and the Admiralty, subject to the Treasury, rather than for the Board of Trade.

Electric Light in Spain.—The central lighting station at Durango (Bilbao) has just started operations, the streets of the town being lighted by 300 incandescents. The towns of Cestova, Arpeilia, and Azcortia, in the province of Guipuzcoa, where water power is available, also contemplate central stations. A central station is also projected for the town of Oreuse.

Barnet.—At the meeting of the Barnet Local Board last Tuesday, the account sent in by the electric lighting contractor was referred back to the Finance Committee for further consideration. Complaint was made of the irregularity of the lighting and the smallness of the allowance made for defects. It was stated that the allowance for the past three months was only 21s. 6d.

Scarborough.—At the monthly meeting of the Scarborough Town Council, held last Monday, the Sanitary and Lighting Committee reported that communications had been received in reference to the electric lighting of the borough from Messrs. Drake and Gorham and from the Anglo-American Brush Electric Light Corporation. The committee had referred the communications to a sub-committee for consideration.

Chelsea Vestry.—At a meeting of this Vestry last week, the surveyor reported that the London Electric Supply Corpora-

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tion had agreed to all the alterations in its Provisional Order which the Vestry demanded. He would, therefore, like the Vestry to authorise the chairman of the Electric Lighting Committee to attend the Board of Trade inquiry and withdraw the notice of opposition. The suggestion was acceded to.

Accident at Deptford.—About noon on Tuesday last the bursting of a steam-pipe at the station of the London Electric Supply Corporation now in progress at Deptford carried away a staging on which were a number of men, precipitating some of them into a pit below. One man, who had sustained serious injury to his back, died before reaching the hospital, and three other men seriously injured were taken to the Seaman's Hospital at Greenwich.

Overhead Wires.—In the House of Commons on Monday last, in answer to a question of Sir G. Campbell's, Mr. Ritchie said he had communicated with the President of the Board of Trade, who was considering the possibility of making regulations with regard to overhead wires, but no power could be given to local authorities to deal with this matter without legislation, and the Government did not at present propose to introduce a Bill on the subject.

The Birmingham Exhibition.—On the application of Mr. T. C. Sharp the Board of Trade have certified, under the provisions of the Patents, Designs, and Trade Marks Act, 1883, that the Electric and Industrial Exhibition to be opened at Bingley Hall in August is to be regarded as an International Exhibition. The arrangements are progressing satisfactorily, and the demand for space gives promise of an unqualified success being achieved.

International Novelties Exhibition.—An exhibition will be opened on May 29th, in the Central Hall, Holborn, at which it is announced that the latest novelties in the arts, sciences and manufactures which have been produced at home and abroad will be on view. Great care will be exercised by the committee of selection to admit only those exhibits possessing the most recent and improved designs. The exhibits will include, amongst other things, machinery in motion, scientific instruments and applications of electricity.

Damage from Lightning.—A severe thunderstorm passed over the south-west of Devonshire at midday on Saturday. One of the pinnacles of Walkhampton Church, on the fringe of Dartmoor, was struck by lightning, and serious damage was done. ——The parish church of Cowden, Kent, was seriously damaged by lightning on Tuesday evening. The spire was struck, and the shock passing downwards carried away a large portion of the steeple. Some damage was caused to the hammer of the great bell and to the interior of the church.

Cowles Patents in Germany.—The Cowles patents for the manufacture of aluminium alloys by electricity have been upheld by the German courts. This decision is the outcome of an action for the revocation of these patents, which was recently brought forward by Dr. H. Kunheim, of Berlin, who relied on the so-called anticipations of Sir W. Thomson (1879), Benzon (1858), Faure (1882 and 1883), and John Calvert (1856). The Heroult process, which is employed at Oerlikon, is not, so we are informed, patented in Germany.

North Staffordshire Mining Institute.—A meeting of the members of this Institute was held on Monday evening at Stoke-on-Trent, Mr. James Heath presiding. A Paper was read by Mr. T. M. Winstanly Wallis on "Electricity as Applied to Coal and other Mines, &c." In reply to an expression of disappointment that the Paper had not dealt with electricity as a motive power, Mr. Wallis said the transmission of electricity as a motive power was quite as large a subject as its use for lighting. A vote of thanks was accorded to Mr. Wallis for his Paper.

Brighton.—The Gas Committee of the Brighton Town Council recently received a letter from Viscount Torrington, Chairman of "Crompton and Co., Limited," inquiring whether the Committee would be willing to consider a scheme for the lighting of Brighton by electricity. It was resolved that Viscount Torrington be informed that the Gas Committee are not at present in a position to entertain a proposal for the supply of electricity in the borough. At a subsequent meeting of the Town Council the proceedings of the Committee were unanimously confirmed.

The Lighting of the Queen's Yacht.—The *Portsmouth Times* says:—"The electric light has completely spoiled the attractiveness of the Royal yachts as floating palaces; hence the Queen's determination not to sleep on board the "Victoria and Albert" in setting out from Cherbourg. When Her Majesty remained on board for a whole night at Portsmouth it was impossible to sleep in consequence of the horrible din kept up by the machinery, and though various improvements were effected on the yacht's return to this port the machinery is anything but perfect yet." Somebody should be hung.

Electric Fire Alarm System at the British Museum.—A complete system of electric alarms has been fitted at the British Museum by H. Dale and Co., of Ludgate-hill. Pulls with special indicators are arranged in various parts of the building in communication with the firemen's room and with the front hall of the building. Upon any alarm being given not only are the police and firemen, by means of an annunciator, informed of the situation from which the alarm is given, but by an automatic relay an alarm is also given at all the entrances and in the principal librarian's house. The arrangements have met with the entire approval of the authorities.

Ipswich.—The introduction of the electric light into the reading room of the Mechanics' Institute at Ipswich was celebrated last week by a conversazione. The installation, which has been put in by Messrs. Laurence, Paris and Scott, of Norwich, under the direction of their local manager, Mr. W. B. Sisling, comprises one 200 candle-power and several 16 candle-power incandescents, the current being supplied from the central station in Carr-street. Amongst the numerous scientific exhibits which were shown on this occasion was one of Edison's perfected phonographs and two half horse-power electric motors made by Messrs. Laurence, Paris and Scott. The light gave universal satisfaction.

Ward's Electric Omnibus.—At the last meeting of the London County Council the Highways Committee reported that they had had before them a letter from the Commissioner of Metropolitan Police stating that an omnibus propelled by electricity occasionally traversed the streets within the hours prohibited for locomotives, and asking whether the Council thought it desirable that any action should be taken in the matter. Having regard to the fact that the Committee understood that the vehicle caused neither noise nor obstruction, they recommended that the Commissioner be informed that in the opinion of the Council there was no necessity, at all events at present, for any action to be taken. The recommendation was adopted.

The Purchase of the Submarine Cables.—The Eastern Telegraph Company have issued the following notice:—"As a certain amount of doubt appears to exist as to the cables which have been taken over by the Government from the 1st inst., I take this opportunity of pointing out to you that the lines which are now being worked by the Government are the cables which connect Great Britain with France, Belgium, Holland, and Germany. Messages intended for India, all places beyond India, Egypt, South Africa, Turkey, Greece, Gibraltar, Malta, the East and West Coast of Africa, Spain, and Portugal should still be handed in at this Company's stations, or if sent from a postal telegraph station should bear the indication *viâ Eastern*."

The Mix and Genest Microphone.—Many of our readers are no doubt aware that in the Mix and Genest microphone the sound-plate consists of a thin diaphragm of finely-fibred firwood. The acoustic qualities of the material are most excellent, but it absorbs moisture very freely, and is consequently liable to get warped and disturb the adjustment of the carbon contacts. After trying several kinds of varnish without obtaining good results, Messrs Mix and Genest now cover both sides of the sound-plate with a thin plate of mica, which is found to protect the wood very effectively, and if not cemented on to it the mica in no way interferes with its acoustic qualities. This improvement naturally renders this form of microphone very suitable for damp climates.

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Edison's New Phonograph.—A large party of the Press were entertained by Colonel Gouraud at lunch on Saturday afternoon at the Gainsborough Gallery, and afterwards to a private view of the latest and most improved form of Edison's phonograph. The new model, weighing only 34lb. including the new pedal motive power, is in marked contrast with Edison's first model, which was also on exhibition, having just arrived in this country, and which weighs over 100lb. The new model can be worked either by pedal or by the electric current. These various machines are now on exhibition at the Gainsborough Gallery, 25, Old Bond-street, and as the phonograph now appears to have emerged from the experimental into the practical stage, it is to be hoped that no time will be lost in perfecting the manufacturing facilities, so that the public may be enabled to benefit by the use of the invention.

Exports of Electrical Apparatus.—The exceptionally favourable features of the trade returns for March, which have been published this week, have been reflected in the shipments of telegraphic wire, &c. It will be remembered that the exports for 1888 were about 36 per cent. less than in 1887, and were 47 per cent. less than in 1886. The value of our exports under this head last month was, however, exceptionally high, and as there had been also a considerable increase in January, the aggregate exports for the quarter ended March 31st are not very far short of the total for the previous twelve months. The following is a comparative monthly statement of exports to the end of last month:—

	1887.	1888.	1889.
January.....	£14,442	..... £41,231	..... £112,230
February ...	44,137	 14,051	 32,086
March	73,300	 32,795	 285,993
The quarter	£131,879	..... £88,077	..... £431,309

The Newcastle-on-Tyne Meeting of the British Association.—The list of officials for the coming meeting of the British Association, which will take place early in September next at Newcastle-on-Tyne, under the presidency of Prof. Flower, F.R.S., has just been arranged. Captain Abney will preside over the Mathematical and Physical Science Section; Sir I. Lowthian Bell, F.R.S., over the Chemical Science Section; Prof. Edgeworth, M.A., F.S.S., over the Economic Science and Statistics Section; and Mr. W. Anderson, M.Inst.C.E., over the Mechanical Science Section. The following are the arrangements for the meeting as far as they have been completed:—The first general meeting will be held on Wednesday, Sept. 11. The succeeding evening there will be a *soirée*; on Friday evening, a discourse on "The Hardening and Tempering of Steel," by Professor Roberts-Austen, F.R.S.; on Monday evening, September 16, another discourse; and on the next evening a *soirée*. Excursions to places of interest in the neighbourhood of Newcastle-on-Tyne—including, of course, the Roman Wall—are being arranged for Saturday, Sept. 14, and Thursday, Sept. 19.

Royal Institution.—The following are the Lecture Arrangements after Easter:—Dr. Jean Paul Richter, three lectures on The Italian Renaissance Painters: their associations, their education, and their employment (with illustrations); Prof. E. Ray Lankester, four lectures on Some Recent Biological Discoveries; Mr. Eadweard Muybridge, of Pennsylvania, two lectures on The Science of Animal Locomotion in its Relation to Design in Art (illustrated by the zoopraxiscope); Prof. Dewar, five experimental lectures on Chemical Affinity; Mr. Joseph Bennett, four lectures on the Origin and Development of Opera in England (with musical illustrations); Prof. W. Knight, of St. Andrews, three lectures on (1) The Classification of the Sciences, Historical and Critical; (2) Idealism and Experience in Philosophy and Literature; (3) Idealism and Experience in Art and Life (the Tyndall Lectures). The Friday Evening Meetings will be resumed on May 3rd, when a discourse will be given by Sir Henry Roscoe, M.P., on Aluminium; succeeding discourses will probably be given by Prof. Dewar, Prof. Silvanus P. Thompson, the Rev. S. J. Perry, Prof. D. Mendeleef, Mr. A. Geikie, Mr. C. V. Boys, and other gentlemen.

Sir R. Rawlinson on the Electric Light and Gas.—At the general meeting of the Commercial Gas Company on the 5th inst., Sir R. Rawlinson (a shareholder) expressed his gratification at the reduction which had been made in the price of the Company's gas—from 2s. 6d. to 2s. 4d. per 1,000 cubic feet—as, he said, a very difficult task was coming before gas directors. At that moment a very important inquiry was taking place in connection with electricity before the Board of Trade as to granting permission for the laying of mains and the introduction of street and domestic supplies. His object in addressing the meeting was to urge the directors to bend their energies to meet the difficulty before them by doing their utmost to making the best possible gas at the lowest possible price. A moiety of the complaints against gas arose from defects in the service or the burners, and if the companies would devote their attention to preventing the extension of such complaints they would be doing much to defeat the opposition which was springing up. He had necessarily had to attend a great deal to electricity, and there was no escaping from the fact that it had to a certain extent established itself. He thought it possible that some wealthy persons might choose to give the electric light the preference over gas, but he was absolutely satisfied that the electric light had no chance of ever coming into competition with gas for street lighting, for the general purposes of illumination, or for the domestic purposes of fire and cooking. He knew from information that had been conveyed to him that in the best and most successful cases of electric lighting for domestic purposes the cost was at least double, and in most cases threefold, what it would be for gas. Gas companies must not in the slightest degree despair because a million or two of capital had been subscribed, grand stations were being built, and millions of lights were being introduced into London. All this should simply put them on their mettle.

Iron Sheathing and Speed in Long Cables.—Mr. A. E. Kennelly writes to the Editor of the New York *Electrical World* on the above subject as follows:—In the application of the duplex system to long submarine cables it is always admitted that the artificial line should be the exact representation of the actual cable in respect to resistance and electrostatic capacity, both singly and jointly considered. That this is, moreover, the true representation of the case is proved by the fact, to which I can personally testify, that there is more than one case on record where the artificial lines having been made with great care as faithful copies of the cables for which they were prepared, were found on application to balance them for duplex immediately with little or no adjustment. Of course this is not the general experience, and much time is sometimes required to adjust an artificial line before balance is obtained, but this is always found to be due to imperfection in the imitation of the cable's resistance and capacity, and the principal must, on due examination, be admitted that a perfect artificial line would be a perfect counterpart of the resistance and capacity in the actual cable, both individually as well as in their mutual relationship. This is equivalent to the assertion that a long cable sheathed with iron may be balanced for duplex by an equally long imaginary cable of precisely similar core, but no iron sheathing. Hence it follows that there is no appreciable effect of electro-magnetic induction, for if it existed it is evident to anyone who has measured electro-magnetic induction, that in order to obtain balance between duplicate, actual, and artificial cables it would be necessary to insert a corresponding amount of electro-magnetic capacity in the latter, or what in this case would be an equivalent resource, to diminish the electrostatic capacity of the artificial line, particularly near its commencement. Hence the acknowledged coincidence in the proportions of resistance and capacity throughout the nearer sections of actual and artificial cables conclusively proves experimentally the results obtained mathematically by Thomson, Heaviside and Charles Hockin, to the effect that the iron sheathing of long cables has no depreciatory influence on their speed of transmission. On the other hand, it is well known that very short cables worked at high speeds when balanced for duplex require less electrostatic capacity than a perfect imitation in their artificial line would demand, and this may perhaps be due to the effect of electro-magnetic capacity from the influence of their sheathings under those conditions of high speed and comparatively small retardation."

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EXPERIMENTAL LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You made a valuable suggestion some time ago (*Electrician*, November 2, 1888, p. 810) that at many telegraph stations abroad it might be possible to set up lightning conductors for experimental purposes, and thus accumulate experience concerning their behaviour more rapidly than by waiting for storms and visiting damaged buildings in this country.

You have asked me to make some suggestions as to how they should be rigged up, and what should be tried; and I should be glad to make such suggestions if they are likely to be any help. Skilled observers, who are frequently favoured with storms, will soon accumulate experience enough to render unnecessary any suggestions from me.

But to begin with it may be useful to draw up a few notes on the subject, and I accordingly transmit herewith a Memorandum which you may see fit to insert in your far-reaching paper.—Yours faithfully, OLIVER J. LODGE.

University College, Liverpool, March 30, 1887.

Memoranda with regard to the Erection of Experimental Lightning Conductors at Telegraph Stations Abroad.

1. It would not be wise to erect anything experimental on an inhabited building, still less on a building utilised for telegraph purposes. A detached shed or a flagstaff is a more suitable support for an experimental rod. A shed offers rather more scope for experimenting than does a flagstaff, though perhaps it is less likely to be struck. There are, however, a few experiments which can properly be made *in the neighbourhood* of an actual lightning conductor, always provided that it be not tampered with in the least. (*See* § 10 *et seq.*)

2. To gain experience as to the advantage or disadvantage of very thick conductors, a couple of conductors might be erected on the same shed or on a pair of adjacent poles:—one a very stout copper rod, the other a quite thin iron wire, even so thin as No. 27.

3. A lightning conductor might be erected on a pole, consisting of various thicknesses of wire in series. Suppose, for instance, iron wire is used. It should be No. 1, or very thick, at the top where the lightning strikes, because that is the place where local melting is almost certain; then it might change to No. 5, No. 8, No. 12, No. 16, No. 18, No. 20, and then once more to No. 5 to take it properly to earth. It would be instructive to find some of these wires melted and not others.

4. An obvious modification of the above experiment is to join copper and iron in series alternately, to use strip in some places instead of wire, and otherwise to vary the circumstances, but always making thoroughly good joints.

5. A distinct conductor might be erected, say of No. 5 iron, with a purposely bad joint, say ¼ inch gap, to see what happens there. At another part of the same conductor there might be an imperfect joint, the parts in contact but not joined properly.

6. Since it is the object to get these conductors struck, rather than to dissipate atmospheric electricity silently, it may be well to terminate them with knobs instead of points.

7. As detectors, to record whether a given rod has been struck or whether a flash has passed in a given direction, one may suggest—

(*a*) A small steel bar or needle placed pointing east and west at right angles to the conductor; to be tested after a storm for magnetism with a compass needle.

(*b*) Some form of lead or tinfoil fuse or cut-out inserted in the length of the rod itself.

(*c*) A branch cut-out adjusted in a tapping circuit, say a bit of wire joined to two points of the conductor a few yards apart, and having included in it an exceedingly fine piece of platinum or other wire to be destroyed by the branch current.

(*d*) A similar branch or tapping circuit, say of No. 16 wire, coiled several times round a quill glass tube containing a sewing needle; to be tested for magnetisation.

(*e*) Some form of registering Cardew or other voltmeter might be similarly connected to two points on the conductor.

(*f*) An Abel fuse or other convenient explosive might be used.

(*g*) A small bulb containing a mixture of hydrogen and oxygen, with a pair of Pt wires close together, would furnish evidence of a very minute spark.

8. To observe side-flashes, a short supplementary conductor, with a detector in its course, could be led from an independent earth to near a point on the conductor a few yards above ground, leaving, say, half an inch gap. A side spark might very well occur across it.

9. Side flashes may also occur to quite insulated conductors—for instance, a rod hung inside the shed on silk or glass or paraffin, with one end near the conductor; only the amount passing in this case, being small, is not so easily detected. A gas leak, or an Abel fuse, is the readiest way of obtaining a record of the passage of a small spark.

10. Near a main conductor—a real one or an experimental one—supplementary short rods might be erected, some earthed, some insulated, and at varying distances from the main conductor. Each of these conductors should have a detector in it, and induced surgings in totally disconnected conductors may then be observed, without any side-flash to them.

11. A horizontal incomplete circuit of wire may have one end connected with the lightning rod and the other end arranged anywhere. Spittings off are likely to occur from this free end, even though it be curved upon itself and brought back close to its beginning.

12. Along the walls of a shed a series of detached conductors, tinfoil strips, or thin wire, may be arranged, with moderate gaps between. They are very likely to spark into one another when a flash occurs, whether the final one of the series be connected to earth or not.

13. A pair of insulated wires arranged close together anywhere near the conductor but quite disconnected from it—one end of one being connected to the ground, and the other end of the other being connected with anything fairly insulated—are very likely to have a spark pass between them when a flash occurs. One way of proving the passage of such a spark is to have a powerful battery permanently joined to the two wires through a cut-out, for the spark will then start an arc.

14. Entirely uninsulated things, such as gas and water pipes, are liable to spark into each other when a flash occurs; and this also may be detected by a sufficiently sensitive recording arrangement, such as a suitably arranged gas leak, or the detonating bulb mentioned in 7 (*g*).

15. In all cases the best possible earth should be made for the experimental conductor, and by frequent testing no loophole should be left for any extraordinary and interesting occurrence to be explained away by the stupid and commonplace exclamation, "bad earth."

16. It seems to me at present of most interest to prove the existence under real lightning circumstances, and with a *perfect* conductor, of electric surgings in all manner of unlikely places—between insulated bodies, between earthed bodies, between bodies at a considerable distance from the disturbance. It will then be desirable to ascertain whether or not such surgings are not more violent when the lightning conductor is a stout rod than when it is a very thin wire, which is deflagrated while acting as a protector.

Manifestly the best protector is one which conducts the flash to earth and which yet sets up least side-flashing and surging. The object of the experiments, therefore, is largely to determine what it is that best satisfies those conditions, and at the same time to note and record all concomitant circumstances of interest. OLIVER LODGE.

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REVIEWS.

The Scientific Papers of the late Thomas Andrews M.D., F.R.S., Vice-President and Professor of Chemistry, Queen's College, Belfast. With a Memoir by Profs. P. G. TAIT, M.A., and A. CRUM BROWN, M.D. (London: Macmillan and Co. 1889.)

By his researches on the constitution of ozone, by his discovery of the "critical temperature" and the "continuity" of the gaseous and liquid states, and by the accuracy of his determinations of the heat liberated or absorbed in numerous chemical reactions, Dr. Thomas Andrews has secured an honourable and a permanent place upon the roll of experimental philosophers, and has well deserved the recognition afforded by the publication of a collected edition of his Papers. Dr. Andrews' work—or at least the most original and important part of it—lay chiefly upon the borderland betwixt Chemistry and Physics, and in this department he was one of the very earliest, and during his own life-time one of the most distinguished, workers in our own country. It is, however, somewhat singular to note that the study of electrolytic phenomena, which afford the most conspicuous examples of the interaction of those processes which are distinguished as "physical" or "chemical," engaged but little of Dr. Andrews' attention. In fact, out of the fifty-one Papers in this volume only nine deal with electrical subjects, six out of the nine being, however, concerned with electrolytic or voltaic action.

At the Newcastle meeting of the British Association, in 1838, when Andrews was twenty-five years of age, and had already settled in Belfast as a physician, he read a Paper of some importance on "The Influence of Voltaic Combinations in Chemical Action." In this Paper he showed that with dilute sulphuric acid the effect of the presence of an electro-negative metal upon the rate of solution of pure zinc was to retard the action if the acid was present in any greater proportion than "one atom [molecule] of the dry acid to seven atoms [molecules] of water," but to accelerate it if the solution was more dilute. He also pointed out that seven molecules represents the water of crystallisation of sulphate of zinc. From this and other considerations, Andrews drew the conclusion that "the proper tendency of a voltaic circle is to diminish the chemical action of the solution on the electro-positive metal." Although this view scarcely accords with modern ideas, it is of interest because in supporting it Andrews incidentally shows that he was strongly inclined to believe that every case of "ordinary solution" is fundamentally an electrical phenomenon.

In the same year he published two other memoirs upon this subject, and arrived at a general law, which he stated in the following terms:—

"*The contact of an electro-negative metal increases the ordinary action of an oxy-acid upon an electro-positive metal if the acid is so dilute that the latter becomes oxidised from the decomposition of the water, and retards or arrests that action if the acid is so concentrated that the metal is oxidised from the decomposition of the acid itself.*"

Seventeen years passed away before the appearance of another paper by Dr. Andrews upon an electrical topic. Meanwhile he had been hard at work at the Royal Belfast Academical Institution (where he now occupied the Chair of Chemistry) upon his thermo-chemical investigations, and had also commenced his now classic research upon the constitution of ozone. The Paper just alluded to is entitled "On the Polar Decomposition of Water by Common and Atmospheric Electricity," and is somewhat noteworthy from the fact that it contained an explanation of the cause of the uncertain and discrepant results which had attended the experiments made by Faraday in 1883 (*Experimental Researches*, § 328) upon the decomposition of water by frictional electricity. Dr. Andrews showed that it was only necessary to operate in tubes of small diameter where the evolved gases would quickly dissolve to saturation in the electrolyte in order to obtain perfectly concordant results.

Of his great research on the constitution and properties of ozone we cannot here say anything—although electricity played a prominent part it was rather as an instrument than as a subject of inquiry.

The last electrical Paper is one dated 1875, on "Electro-Magnetic Machines and Recent Improvements in them, by M. Gramme." This was a lecture delivered to the Belfast Natural History and Philosophical Society. It contains a complete analysis of Pacinotti's memoir from *Il Nuovo Cimento*, 1865, with *fac similes* of the three original drawings. This is the best account of Pacinotti's work in the English language that we know of. The Paper exhibits a grasp of the subject which is scarcely less than surprising for the period in question.

How to Make a Dynamo. A Practical Treatise for Amateurs. By ALFRED CROFTS. (London: Crosby Lockwood and Sons, 1889.)

The instructions given in this unpretentious little book are sufficiently clear and explicit to enable any amateur mechanic possessed of average skill and the usual tools to be found in an amateur's workshop to build a practicable dynamo machine. We hope and anticipate that it will be the means of inducing many amateurs to try their hands at the task, and we also hope that the success which they may achieve will induce them to study more deeply the scientific principles which underly the design, about which Mr. Crofts has probably done well in saying very little. We cannot quite agree with the author in his estimate of the extent to which we are indebted to the "amateur" for the progress of electrical science; but since he calls Faraday an amateur, it is probable that our disagreement is a question rather of definition than of fact. The book is one which can be recommended as fulfilling very fairly the purpose for which it has been written.

THE BOARD OF TRADE INQUIRY ON THE LONDON ELECTRIC LIGHTING PROVISIONAL ORDERS.

This Inquiry has been continued at the Westminster Town Hall since our last report. The following gentlemen represented the various parties concerned:—

Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham appeared for the London Electric Supply Corporation; Mr. C. A. Cripps for the Metropolitan Electric Supply Company; Mr. Moulton, Q.C., and Mr. R. S. Wright for the Chelsea Electricity Supply Company; Mr. Muirhead for the St. James's and Pall Mall Electric Light Company; Mr. Roger W. Wallace for the Notting Hill Electric Light Company, for the Kensington and Knightsbridge Electric Lighting Company, and for the Westminster Electric Supply Corporation; Mr. Moulton, Q.C., and Dr. Hunter, M.P., for the Electrical Power Storage Company; Mr. G. Prior Goldney (the City Remembrancer) for the City of London; Mr. T. Percy Gunyon (engineer) and two members of the Council for the London County Council; Mr. C. A. Cripps and Mr. F. M. Jenkins for the Strand District Board of Works; Mr. Hopwood (solicitor) for the Holborn District Board of Works; Mr. E. Bayley (clerk) and Mr. G. W. Thompson (surveyor) for the St. Olave's District Board of Works; Mr. James Spencer for the Greenwich District Board of Works; Mr. J. H. Horton for the Paddington Vestry; Mr. Hitchins for the St. George's (Hanover-square) Vestry; Mr. Wilkins (clerk) and Mr. W. Jenkins (chairman of the Lighting Committee) for the St. James's (Westminster) Vestry; Mr. Webster Murnane (clerk) for the St. Martin's-in-the-Fields Vestry; Mr. T. Eccleston Gibb (clerk) and Prof. Robinson, C.E., for the St. Pancras Vestry; Mr. Cripps and Mr. Greenwell for the Marylebone Vestry; Mr. H. J. Smith (clerk) for the Lambeth Vestry; Mr. Harrison (solicitor) for the Bermondsey Vestry; Mr. E. Moore (solicitor) for the Great Eastern Railway Company; Messrs. Payne, Son and Pollock (solicitors) for the North London Railway Company.

THURSDAY, APRIL 4TH (*continued*).

After the evidence of the Earl of CRAWFORD and BALCARRES, Mr. S. DE FERRANTI, the chief electrician and engineer of the London Electric Supply Corporation, was next examined by Mr. GRAHAM, and stated that he had had a considerable amount of experience in electrical matters for some years past. About eighteen months ago he worked out a map showing the different proposed districts of supply and the number of lights to be apportioned to each district. The map also showed the position of every distributing station and the number of lights allocated to each. He had also worked the matter out a second time with Mr. Ince, one of the directors of the company, and discussed the subject a number of times with the different directors. The works at Deptford were commenced about a year ago. Excavations covering a space of 200 feet square were made, and in that buildings were erected to contain the plant capable of working up to 40,000 horse-power. They had just completed the erection of two engines, each of 1,500 horse-power. Two larger engines, each of 10,000 horse-power, are now being erected. He had seen one of the engines of 1,500 horse-power running, and believed the second had been running as well. Each of those sets of engines is easily capable of generating electricity for 25,000 lamps of 10 candle-power. In November next there will be a 10,000 horse-power dynamo ready and another of a similar size in December, when the machinery will be capable of an output of 250,000 lamps. The company

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have also contracted for erecting further plant, which will give, with that already spoken of, a total output of 450,000 lights. He saw nothing remarkable or extraordinary in the size of the engines of the company; in fact, he was rather disappointed that they had not got larger engines, considering the way steamships had increased the size of theirs. The engine of the Grosvenor Gallery had worked up to nearly 900 horse-power indicated. Although the whole capacity of the lamp supply would be 250,000, it was not proposed to work up to more than 150,000, so as to allow a very large margin to facilitate repairs and also to provide an absolute security against failure in the supply to the current. They were going to lay down six mains with concentric conductors between the Deptford generating station and the distributing stations in London—from Deptford to London Bridge. At London Bridge two would go to Cannon-street, two to Blackfriars, and two to Charing Cross. They are carried in cast-iron brackets along the railway. These cast-iron brackets are provided with India-rubber or porcelain supports, on which the cables can be laid. Each main will carry 100,000 10-candle lamps, so that there will be a carrying capacity of 600,000 lights, although it is not intended to work up to that capacity. In the first place, there will be an enormous margin in the mains. Later on it may be found desirable to have less, but it is always proposed to have a considerable margin in the mains. The mains are so arranged that any one of them may be thrown into connection with any other of them at Deptford, so that to have a total failure of lighting there must be a total breakdown of both engines and mains at the same time. There will be two mains at least in each distributing station, supplied from two separate dynamos, so that the supply is in duplicate, and to have a failure of current from the distributing station both the sources would have to fail. If one only failed from any cause, the other would be of ample capacity to supply the whole demand. In the event of a breakdown in the converter the current would be thrown over by a switch to the other supply, and the converter itself will be cut out by its own fuses automatically. The loss of potential in the Deptford trunk mains he calculated to be one-fifth per cent. per mile run. With respect to the insulation between the inner and outer conductors, he had tested the insulating capacity in a number of lengths up to 1,000,000 volts without getting through or injuring insulation in any way; therefore, with the pressure at which it was proposed to work that would give a safety margin of 100 to 1.

In further reply to Mr. GRAHAM, Mr. FERRANTI said the system proposed by his company has been carried out at Nancy (which has 10,000 lights at the present time). It was also used at first on a large scale at the Grosvenor, but the space available was too small for the plant, which is placed on a number of different levels averaging 25ft. below the street. It was almost impossible to ventilate the place, and the greatest troubles arose from that.

In cross-examination by Mr. MOULTON, who appeared for the Chelsea Electricity Supply Company, Mr. FERRANTI thought every detail of the system proposed by his company was special to the London Supply Corporation, and that success depended principally on details. He thought the amount of coal required per day for 100,000 lights would be 200 tons. He was not prepared to say it would take only 20 on the storage system. He was not acquainted with what they took. As to injunctions, they had had a good deal of trouble with them at the Grosvenor. He had never personally stated that the complaints were unfounded. The company had. With regard to the size of the dynamo, he did not think it was a new experiment, insomuch as the design of the dynamo makes it a combination of a lot of small ones. It was twenty times the size of the one at the Grosvenor. The tension of 10,000 volts at which they work is four times the pressure that has been ordinarily used in London. At Nancy all the wires are underground, working at a pressure of 2,400 volts, the same as at the Grosvenor. There had been cases in which the converters leaked from the primary to the secondary; they had been badly made. In the case of such a leak it would not mean bringing a tension of 10,000 or 2,400 volts into the houses, as the use of their automatic cut-out apparatus would prevent that. It works by burning the fuses which supply the house, and the current is absolutely cut off at the consumer's door. Coming back to the question of insulation, the majority of mains at the Grosvenor were overhead, and some trouble had arisen with them. At Nancy there had only been one single fault, which he thought showed that underground wires are better than overhead wires. The underground wires of the Grosvenor are partly under the Park. They are not tapped every few yards, because consecutive houses are not supplied.

Lord CRAWFORD, in reply to Major MARINDIN, said: The wires run from the back of the War Office to Marlborough House, from thence back to the War Office gate to the corner of Spring-gardens. That is one underground main. Our second one runs from Walsingham House, at the north-east corner of the Green Park, and runs along the south side of Piccadilly on Crown property as far as St. George's-place, at the corner of Hyde Park, and thence it crosses into Hyde Park, also on Crown property, runs on to Albert-gate, whence it is laid under the Pavilion-road as far as Sloane-square. Those are our underground mains. They cross Piccadilly by permission of the local authorities.

Mr. FERRANTI: The underground mains are tapped in many places. There were about 280 installations altogether. At Nancy the mains are tapped every few yards.

Friday, April 5th.

Mr. FERRANTI, on being recalled, was further cross-examined by Mr. MOULTON: He said that the conductors were rigid, and were therefore made in lengths. The Edison Company in New York had found some difficulty in connecting rigid mains, but he thought he had got over the difficulty. The mains at Nancy were all concentric. They consisted of stranded core, then insulation, then wire stranded round that again. They proposed to connect to earth at the Deptford end, but to insulate along the line in order not to disturb telephone and telegraph work. They had experimented on the Underground Railway to see whether concentric mains supplying the current put to earth at one end would give a shock, and they could not feel it. In a long main there would be perhaps 100 volts shock if you got to the bare copper; this was only the ordinary pressure in a house. He did not object to the clause in the order for providing testing stations at various points of the mains if they were to be mere boxes in the street, but he objected to paying rent for places where the mains could be tested. At the Grosvenor Gallery the station is under the demand, and the dulness of the lights is due to the want of steam and nothing else. For fairly complete electric lighting about one light per head of the population is a fair allowance, and the present plant would be equal to a population of about 250,000 allowing for lights not used. He did not know whether his company had entered into any arrangement with the Chelsea local authority. He had heard a good deal talked about Chelsea, but personally he did not know of any agreement.

Cross-examined by Mr. SHIRESS WILL, representing the House-to-House Company: The whole success of the scheme rests upon the power to carry the electricity at the tension of 10,000 volts for the distance of seven miles and maintain insulation along the route. As regards the coal question at the Grosvenor, he reckoned that it would take 100 tons of coal a day in the winter time to maintain 100,000 lights of 10 candle-power; that was calculated on working with 10,000 horse-power at 5lb. of coal per horse-power per hour 10 hours a day with non-condensing engines. With the first-class machinery the company proposed to work with at Deptford it would be nothing like that.

Cross-examined by Mr. WALLACE: As the rigid concentric mains were a modern idea he had had no lengthened experience of them, but he had considerable experience with flexible India-rubber concentrics. The distance from Deptford to the Westminster Underground Station would be about seven miles. Up to London Bridge the mains would all be carried together on the wall of the railway. In the event of anything happening to that wall the whole of the area would be in darkness until they had got power to take another route. The company had another route by the London, Brighton, and South Coast Railway, but they must lay one route before they could lay a second. After their orders were right they would bring another set of mains up by the roads. They proposed to cross streets with the rigid concentric mains in the same manner as gas and water-pipes were carried. Where they were laid under the foot-pavement they would be carried as near the surface as possible, as there would be no danger of heavy weights. In crossing the roads no doubt they would dip down.

Cross-examined by Mr. LYTTLETON: The electrical difficulties at the Grosvenor Gallery were due to their very confined position and numerous other disadvantageous circumstances of position. They were twice flooded by a leaky sewer.

Mr. MUIRHEAD, representing the St. James's and Pall Mall Electric Lighting Company, cross-examined the witness as to the advantages of supplying electricity to the St. James's district from Deptford as against local generation.

Cross-examined by Mr. RUSSELL GRIFFITHS: He did not say that every light would run 10 hours out of the 24, but that the running during night and day would be equal to that; but he did not think that applicable to the City. The street lamps, taking fogs and everything into account, would run about 4,000 hours a year. He did not know that there were 3,000 street lamps in the City that would require lighting, but if that were the number it was nothing very frightful. If they were proposed to be 2,000-candle arc lamps he thought it would be excessive for every lamp-post. He thought 600 arc lamps would be sufficient to replace the 3,000 gas lamps existing at present; but it was only an estimate. That would exhaust about 400 horse-power, or about 9,000 of the lights we are able to supply. Up to seven o'clock at night, at which time the great bulk of the people would have cleared out of the City, they would be prepared to supply, publicly and privately, an equivalent of 100,000 ten-candle lights. According to Lord Crawford they had at present applications for 70,000 lights in the City, all of a private character, which would make, with the public lamps, 79,000 lights, besides any further applications that might be made. The proposed system did not necessarily require a transformer in each house—under certain circumstances there might be one to 20 or 30 houses. They could group the lamp-posts by running a separate circuit with the requisite pressure and put the lamps in series, say 20 lamp-posts to a group with one transformer. The transformers would not be in the streets, but at the distributing station, and worked with ordinary wires, which would be in the streets, the same as if the lamps were lighted by the ordinary direct supply. He had heard of the same system being used in America. With reference to the future development of electricity, he would not go so far as to say that electricity as a motive power would throw the use of it for lighting purposes completely into the shade, but the supply for motive power would be a more profitable one commercially, and would be much more in demand. They had not as yet commenced supplying electricity from their Deptford station. Mains are at present being laid across Blackfriars Railway Bridge. They had permission to take them along the Underground Railway, and they would do that. They would supply their present Grosvenor customers from the Deptford mains, Maiden-lane, and the Grosvenor would be a distributing station. He had not worked out the cost of lighting a street lamp under the arc system. He considered that public lighting would be the reverse of important to the Company. It would be commercially better for the Company if they could get what they wanted without doing the public lighting at the price which, as a rule, is proposed.

Cross-examined by Mr. WILKINS, clerk to the St. James's Vestry: There is no motor at present in the market which is applicable to the alternating current, but there is one likely to be in the market. He had tried a small one and tested it, but was not prepared to give any material information at present—it was not yet commercial. He was not going to say how long it would be before they were in the market. He could not say off-hand what proportion the cost of the

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main bringing the current from Deptford to St. James's would bear to the cost of plant used in generating the current—he had not worked out the percentage. If the cost of the plant for generating the current at Deptford was £200,000, the cost per mile of bringing the current to St. James's would be a matter of proportion. He could not carry every figure in his head, but if Mr. Wilkins would formulate a question so that he could make a calculation on it he would do so.

Mr. WILKINS: I do not think I can formulate the question better than I have done—What is the proportion between the cost of the plant and the cost of the mains for conveying, say 100,000 lights, 10 candle-power for seven miles—that is, to bring it to St. James's.

Mr. FERRANTI said he would take the question down and let Mr. Wilkins have the figures.

[Later in the day the witness in answer to Mr. Wilkins, said that putting the cost of plant at Deptford at 100, the cost of the main would be 7 per cent., practically an inappreciable amount. That included bringing the current from Deptford to the distributing station in St. James's, and would also include the cost of the mains themselves, of the excavations where necessary, and of reinstating the surface.]

Continuing, Mr. FERRANTI said that the saving on coal would be 50 per cent., and that the site at Deptford would be a large saving in many ways on the cost of production. They proposed to give up the Grosvenor Gallery station altogether. Their plant was so much divided at Deptford that it would be impossible for an explosion to blow up the whole of the machinery. They were enormously divided for safety, but they had got no storage station.

Examined by Captain CARDEW: They proposed to work the mains along the railways with a small amount of insulation between them and the earth. The insulation would be at each support, and not continuous. With regard to the test he had made of the insulation with a pressure of 1,000,000 volts, it had been made with a Wimshurst machine, giving over a 12-inch spark.

Re-examined by Mr. GRAHAM: They were perfectly willing to supply any amount of electricity for public lighting purposes—it was purely a question of price. Their object was not to supply motors driven by an alternating current, but to supply electricity and allow the consumer to do what he liked with it. Their objection to the clause relating to testing stations was not with regard to having testings taken, but to having to pay for the ground on which the testing stations are to stand. They were perfectly willing to allow the Board of Trade, or the local people, or anybody else to test so long as the company were not put to the expense of furnishing a room.

Saturday, April 7.

Mr. C. A. CRIPPS, on behalf of the Metropolitan Electric Supply Company (Limited), wished to explain the views of that company with regard to the Provisional Orders they were asking from the Board of Trade. There were two main points which they could easily establish. The first was that the company he represented was in a thoroughly sound financial position, was supported by men of great eminence in financial circles, and, as they had ample capital, if any more were required there would be no difficulty whatever in finding it. The other point was that the system proposed to be adopted by this company was the best and safest, would stand comparison from an economical point of view with any other system, and as regarded safety and convenience to the consumers, it stood in the best position of all. He was not desirous of criticising the views put forward on behalf of the London company, because they did not fear the competition of any other electric company. The capital of the Metropolitan Electric Supply Company was £500,000 in £10 shares. He believed that when the prospectus was issued the amount was subscribed more than twice over, and the number of shareholders was no less than 700. They had come under obligations already to expend £380,000, or any further sum that might be necessary. The directors did not propose to ask for any compulsory powers with regard to the North London Order, the application in respect of which was withdrawn. The first order upon which they asked for decisions was the Mid-London Order, which comprised the City of London and the Liberties, and the following parishes and places in the County of Middlesex:—St. John the Evangelist, Westminster; St. Margaret, Westminster; St. George's, Hanover-square; St. Giles-in-the-Fields; St. George, Bloomsbury; St. Andrew, Holborn-above-Bars; St. George the Martyr; St. Sepulchre, Saffron Hill, Hatton Garden, Ely Rents, and Ely Place; the Liberty of Glasshouse Yard; St. Anne, Soho; St. Paul, Covent Garden; St. John the Baptist; Savoy, or Precinct of the Savoy; St. Mary-le-Strand; St. Clement Danes, and the Liberty of the Rolls, together with the extra-parochial places known as the Charterhouse, Gray's Inn, Lincoln's Inn, Staple's Inn, Furnival's Inn, and the close of the Collegiate Church of St. Peter. The next order to be dealt with was the South London Order, which comprised the following districts: Lambeth, otherwise St. Mary, Lambeth; Christ Church, St. Saviour's (including the Liberty of the Clink); Streatham, otherwise St. Leonard's, Streatham; and Clapham. Then there was the West London Order. As far as Kensington was concerned the company did not ask for a Provisional Order, but they did for Lower Marylebone and Paddington in the West London Provisional Order.

Major MARINDIN: You may strike "St. Mary Abbot, otherwise St. Abbot's, Kensington," out of the schedule.

Mr. CRIPPS: Yes, you may strike that out as well.

Mr. WALLACE, of the Kensington Court Electric Lighting Company, asked Mr. Cripps if he intended to include that portion of St. Margaret's which was attached to Kensington, the outlying portion of St. Margaret's, Westminster.

Major MARINDIN: That is in the Mid-London Order.

Mr. CRIPPS: We propose to have a station at Whitehall with a capacity of 12,000 lights; we have arranged for a station at Sardinia-street with a capacity of 50,000 lights, at Rathbone-place with 24,000 lights, Manchester-square with 50,000 lights, Eccleston-place with 40,000 lights, and Waterloo Bridge with 20,000 lights.

Major MARINDIN: Are all those arranged for?

Mr. CRIPPS replied in the affirmative, and proceeded to state, with reference to the City, that they had purchased a wharf, known as Greenmore Wharf, which gave them a centre capable of and convenient for supplying the City district. This wharf would be able to carry a plant of a capacity of 120,000 lights. The Whitehall station was supplying a very compact district by means of the direct-current system and storage batteries. The reasons which had influenced the Metropolitan Electric Supply Company to bring forward their present scheme would be given in evidence. He must deny the various suggestions that had been made as to the costliness of coal with reference to the various generating centres. As regarded the question of noise, vibration, and smoke, they were in a very sound position indeed. Of course Mr. Ferranti had a natural bias in favour of the large centre which he was constructing down at Deptford, whilst the Metropolitan Electric Supply Company had a bias in favour of their smaller centres. They were not seeking a monopoly of supply; they relied only on their system being the best and most efficient. They were not there in antagonism with regard to other companies who sought for powers over the same districts. He would give evidence how far the opposition of the various companies extended against the Mid-London Order. With regard to the City of London Provisional Order, the local authorities affected were the Metropolitan Board of Works—which was again merely a formal matter—the Wandsworth District Board, the Lambeth Vestry, and the St. Saviour's District Board of Works, whose wishes they were desirous to meet. As to the question of overhead wires, they were satisfied they had no powers. As the question of the time within which a supply should be given had been raised, they proposed eighteen months, which he thought a reasonable limit. He need only now say that if the local authorities or any companies wished to bring forward any matter in reference to the area comprised in the Bill, they would have the same power as if they were asking anew for a Provisional Order.

Mr. WILKINS, Clerk to the St. James's Vestry, asked whether Mr. Cripps would undertake to introduce the necessary amendment in Committee to make the Bill conform to the terms of the Provisional Order granted by the Board of Trade.

Mr. CRIPPS replied in the affirmative, and he added, in reply to Mr. RUSSELL GRIFFITHS, that he was willing to introduce into the Provisional Order of his company the same amendment as regards all the Orders that was introduced into the "London," or an amendment to a similar effect.

Sir JOHN PENDER, who was then called and examined by the Hon. ALFRED LYTTLETON, said he was chairman of the Eastern Telegraph Company, director of other telegraph companies, and chairman of the Metropolitan Supply Company. The authorised capital of the company was £500,000, divided into 50,000 shares of £10 each. In August last 43,900 ordinary shares were applied for, and there were now upwards of 700 shareholders on the register; £3 a share had been called up, giving a total of £131,700. Of this sum £40,211 had been expended in the purchase of the Whitehall station. The Whitehall Company was taken over on promotion by the Metropolitan, which had since acquired working stations at Rathbone-place, and were now erecting stations in Sardinia-street, Manchester-square, Eccleston-place, and Waterloo-place. For this purpose the company would have spent £351,000 out of the £500,000 when the stations were completed, which left a large margin for working expenses and moderate extensions if required. If large extensions became necessary, he had not the least doubt they would be able to obtain a large amount of capital.

Cross-examined by Mr. PEMBER, representing the London Electric Supply Corporation: He did not object to a wholesome competition at all.

By Mr. R. S. WRIGHT: He thought the great object was to obtain for the public the cheapest light it was possible to produce for a fair return. Their present system was one of separate installations. That upon which they meant to make their mainstay was the alternating system. He should not object to two companies competing in one district, as that one which brought most practical knowledge to bear on the subject was likely to be successful. He thought the Board of Trade ought to be the judge how far it was desirable for one, two, or three companies to take possession of one particular district. He would start all over London with the parts that were likely to pay best in each parish. They had powers to increase their capital, but they had got over £100,000 to spare. They could call up half a million if necessary. A million would be sufficient for lighting all the streets in the whole area they went for. They were not in Chelsea parish nor in Kensington.

Cross-examined by Mr. RUSSELL GRIFFITHS: He believed that they had secured ample space to supply the district they had taken up.

By Mr. WILKINS: As soon as they had done their one work efficiently they would turn their attention to power.

Mr. C. A. CRIPPS here stated that the Wandsworth Board did not oppose the scheme, but rather wished to render it every facility.

Re-examined by the Hon. ALFRED LYTTLETON: They did not object to reasonable competition. He believed that very great developments would yet take place in electricity.

Mr. JOHN EDWARD HENRY GORDON, examined by Mr. C. A. CRIPPS, said he was the electrical engineer to the Metropolitan Electric Supply Company, and had charge of the designing and working of the various installations. The Whitehall station was worked on a system of direct current and storage batteries. They used in it Siemens dynamos and Elwell-Parker batteries, and had no difficulty as regarded either noise or smoke or vibration. They had adopted in the rest of the stations the transformer system, which was a perfectly safe one. The work at Sardinia-street station was nearly completed. They were preparing it for 50,000 lights. Into the Rathbone-street station they were putting plant for

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24,000 lamps. The Manchester-square station would be capable of working and supplying 40,000 lights. The Eccleston-place station at Victoria would accommodate 150,000 lights, and a large number would be placed at Waterloo Wharf. The company were now spending for machinery about £195,000, on buildings about £50,000, on mains from £80,000 to £100,000, giving a total cost of about £370,000. There was nothing experimental in the system they were proposing. They did not reopen the street—which had only a small demand at first—for every thousand lamps that were ordered, but simply went to a testing box and put in a main and drew it through by means of cords.

Cross-examined by Mr. PEMBER: At the Paddington station the consumption of coal was about 12 tons a day throughout the year for 25,000 lights. In all the others it was rather more economical. They had room for the storage of coal at the stations, besides great facilities at Waterloo Wharf. They had six stations at present, but if they were to supply the whole of the district they would probably treble the number.

Cross-examined by Mr. SHIRESS WILL: They desired to adopt the experience of all countries in this matter—American, English, or European.

By Mr. WALLACE: They could supply a two-mile radius from the Eccleston-place station. They calculated that the lights required in the district would be about one per head of the population. They only proposed to light a small proportion of St. Margaret's, Westminster, from that station, and had made no arrangements for the remaining portion as yet. They proposed to connect the houses with the mains by passing the house mains into the openings at the side of the box, and make a proper joint. The mains could be easily drawn backwards and forwards through these openings. To draw out an old main the joint would have to be cut, but that would have to be done anyhow. It would not be necessary to draw out the whole length of a main in which some connection had gone wrong. Faults could be localised by cutting the connection at a junction box on each side, not at the test boxes, pass a new length of main through, and connect it across before cutting the other, so that the only interruption would be just between those two junction boxes. They were now drawing mains under the pavement in a very small way at Whitehall. None of these mains had required repairing; at Paddington they had repaired frequently. At St. George's, Hanover-square, they proposed to use a transformer station. They were supplying the same alternating current as the London Company, and as soon as a suitable meter came upon the market customers could use it.

Mr. WALLACE here said they would like to have an opportunity of visiting the Eccleston-place station.

Witness continuing, said that plant for it had been ordered of Elwell-Parker, Willans and Wilcox—alternating plant. He had no doubt it could be thrown into parallel.

Cross-examined by Mr. MUIRHEAD: If they got orders for power from St. James's they should very quickly supply it. The alternating-current system could not be used with storage batteries.

Cross-examined by Mr. RUSSELL GRIFFITHS: The lid of the junction box did not appear on the pavement—only the lid of the testing box. The whole process of opening a junction box would take about six hours, and could be done at night. He thought they could find room to put a system of tubes through the city; if there was no room for a full-sized junction box they must modify it. He agreed that there was no known commercial motor that could be used with an electric current. He would place mains 12 inches under the pavement, but under a road with heavy traffic deeper. They would have no overhead wires at all. The Greenmore Wharf, Southwark, intended for the City installation, was between one-third and a-half acre in extent. They would use another wharf for coal storage. 1,000 volts would be the extreme pressure, and a plant could be put on the Greenmore Wharf for 100,000 to 150,000 lights. At present he preferred dynamos of about 200 horse-power each; out of each they would get 4,000 lights. He should advise ten such engines to begin with. The transformer would probably be in a fireproof cellar in the house—as to its position they would be glad to take Mr. Heaphy's directions.

Cross-examined by Mr. J. H. HORTON (Paddington Vestry): They had not yet arranged for a station for Paddington. They would be able to work from South Mews, Manchester-square. Witness put up the Paddington Great Western electric light; the objections were chiefly due to dirt; Mr. Justice North decided that there was no vibration. There had been no complaints for two years.

Re-examined by Mr. C. A. CRIPPS: He looked upon the small unit engine as an economy—either they were working at full power or stopped. At Philadelphia there had been a very instructive instance of one station helping another when the Brush Company had a station burned down.

Mr. RUSSELL GRIFFITHS said there was one very important amendment put in that morning. The company proposed, as in the case of the London Company, to amend section 7, sub-section 7c, by these words: "Provided that nothing in this order should authorise the undertakers to place any electric wires underground, along, over, or across any streets without the express consent of the local authority."

Dr. JOHN HOPKINSON, examined by Mr. LYTTLETON, said this was a system of many stations. With regard to the uniformity of distribution of electricity, it would be much more uniform unless you worked on an exceedingly high potential with few machines; its great advantage was that, as the consumption varied, you could vary the number of machines employed during the small hours of the morning and afternoon, and so on. On the Metropolitan Company's plan one might say that it would be impossible that the supply should fail in any district. It was obvious that bringing a main along a line of railway would increase the danger. They had carefully considered the question of adopting 10,000 volts, or the Grosvenor Gallery 2,000 volts, or to go to 2,500, and had come to the conclusion, although there were some advantages of going to the higher potential, that they would be completely counterbalanced by the possible disadvantage of breakdown in the insulation either of transformers or of mains. There were insulation difficulties even with 2,500 volts. The Metropolitan Company proposed to use one transformer only between the machine and the lamps. They only transformed once, and every transformation meant a loss. This system gave a direct supply, the advantage of which over accumulators lay chiefly in cost. He dared say accumulators would run to £30 per horse-power in the maximum amount put in, and they lost 30 per cent. of power.

Cross-examined by Mr. LOYD: The 1,000,000 volts mentioned by Mr. Ferranti he did not consider a sufficient test of insulation. M. Ferranti spoke of a 12-inch spark.

Cross-examined by Mr. WALLACE: He did not object to accumulators for the purpose of supplementing dynamos.

Cross-examined by Mr. RUSSELL GRIFFITHS: The proper arrangement to prevent disturbance to telegraphic and telephonic wires would be whenever there was a current going out there must be one coming back carrying the same currents within something like six inches. There would be no necessity for a re-arrangement of the telegraphic and telephonic wires.

Further cross-examined by Mr. WALLACE, witness said that they proposed to lay special mains between each of the central stations for the purpose of supplying one another. In case of the destruction of a connection by a fire at any one station they could make a connection outside the building.

Dr. FLEMING, re-called, and cross-examined by Mr. MOULTON, said electricity supplied from storage batteries was undoubtedly favourable to a long life in the lamps, but he did not know that there was anything in the alternating current *per se* which should shorten the life of a lamp. Assuming absolutely constant voltage, the one would not give a longer life than the other. As at present used, the transformers probably shortened the life of the lamps. Transformers were liable to fluctuations of voltage. But assuming that the primary E.M.F. is constant, then there is nothing to cause the secondary electromotive force to vary.

Mr. MOULTON: Not if you put on a large number of lamps? If you load the transformer too much the electromotive force would fall.

Witness continued that there was more difficulty with the transformer in getting that absolute uniformity of electromotive force than with the secondary battery. In the United States the Pittsburg transformer installation of 12,000 or 15,000 lamps was the largest. There was no experience of jointing under anything like the high pressure proposed by the London Company.

By Mr. PEMBER: The transformer system had met with as general adoption in the United States as the direct or storage systems. The strain on the lamps might result from overloading batteries. He had had lamps that lived 7,000 to 8,000 hours.

Dr. HOPKINSON, recalled, and cross-examined by Mr. MOULTON: Variation of voltage—putting too high a potential on lamps—prevented them lasting so long. He should not say it was more difficult to secure uniformity of voltage with the transformer than with the storage battery system. With regard to insulation, the joints were the weakest parts. The real practical question was the probability that faultless joints would be made and maintained during a long run. The Metropolitan Company's dynamo would run about 200 to 250 horse-power.

Re-examined by Mr. C. A. CRIPPS: The variations in pressure could be made lighter with the Metropolitan system than with the battery system, because with the battery system you must go by steps in one cell at a time. Supposing 50-volt lamps were being worked, one of those battery cells would give a potential of about two volts, and so your step must be, say, from 49 to 51 volts—that was a very large difference. He should think the variations under the Metropolitan system could be easily kept within 2 per cent. in the house. As to the variation in the mains, it could be reduced to nil.

Mr. ALFRED HENRY WALTON, examined by Mr. LYTTLETON, said he had been manager of the Paddington works since the Great Western took them over. There had been no complaints for two and a-half years. There had been a slight alteration in the construction of the machines to get rid of nuisance; the field-magnets which revolve had pole plates at the extremities, and the fixed coils on the machine were supposed to have one-eighth clearance all round. On one side of the machine they took out the coils, and shortened them on the top sides, so that they gave a quarter of an inch in front at the left-hand side and a quarter of an inch on the back on the right-hand side. By this means the two sets of coils set up a different note, and so misconstrued one another, and the reduction of noise was found to be considerable. They ran 4,000 lamps of 25 candle-power and about 100 arc lamps from that station.

Mr. THOMAS SPENCER, examined by Mr. CRIPPS, said that he was the engineer of the Westinghouse Company, which company had adopted by preference the transformer system. One thousand volt pressure was employed.

Prof. FORBES, examined by Mr. CRIPPS, said that in his opinion the system proposed by the Metropolitan Company was the best that at present could be adopted. It would preserve a high constancy—the loss in the distributing mains between the feeding points would not exceed one-half per cent. The constancy of pressure was better in high tension than in a low-tension direct supply. The question of the transformers as to keeping the pressure constant was a point of the greatest importance. A fall could not be allowed of more than 3 to 4 per cent. between the hours of maximum and minimum supply. The wiring of the houses generally took 2 per cent. of this, the transformer itself would take 1½, bringing it to 3½ per cent., leaving usually 1½ to play with in the mains. The Metropolitan Company, however, having only one transformer, lost that 1½ per cent. only once. Their system was also highly economical. The E.P.S. was a very interesting but a very costly system, almost prohibitive from an economical point of view.

The INSPECTOR stated that he had been asked to visit the works of the London Electric Supply Corporation. The representatives of the Metropolitan, of the Chelsea, and of the St. James's also invited the Inspector to visit their works.

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The INSPECTOR replied that when he did so it would not be on any scientific point, but merely to get a general idea of their size and site.

The inquiry was then adjourned to Monday.

MONDAY, 8TH APRIL.

Prof. GEORGE FORBES recalled, cross-examined by Mr. MOULTON, said the Metropolitan Company intended to use the transformer system with 1,000 volts pressure, and his preference would be to have each distributing main connected while in action with only one generating source. He had been asked to examine the cost of batteries in many schemes, but had never had one in his own hands as engineer. He had gone into the question of batteries as a source of distribution very carefully quite lately in connection with the proposed lighting at Paddington by the Vestry, but it seemed prohibitive at present. Of course there is a storage of energy in the accumulator system which there is not in the direct supply system. He had seen the transformer system in America, but had never seen it put to earth there. He thought to put the secondaries to earth a very good thing indeed, but he objected most positively to putting the primaries to earth. The system he had seen worked at Berlin was the most economical production of electricity for a central station in the world—that is to say, the combination of engines and dynamos with condensing arrangements, &c. There was less fuel used for the electrical unit given out in the central station than he had ever seen anywhere else. The greatest variation of pressure allowed in the mains at Berlin was 1½ per cent., which was, he thought, a proper regulation, but necessitated enormous expenses for mains.

Cross-examined by Mr. RUSSELL GRIFFITHS: He had had experience of the system now worked at Rome and Milan. At Rome it is altogether alternating—high-tension alternating—at Milan a mixture of three different systems. At Rome the conducting mains are of wire running below the surface. The public and private lighting would be 6,000 or 8,000 lights of 16 candle-power, but it is a new thing, and they are putting down engines as rapidly as they can. The public lighting consists of about 20 or 30 lamps. The biggest engine is of 400 horse-power. The cost of the lighting is pretty high—considerably higher than that spoken of for London. At Milan they have alternating current used for lighting up two large theatres, they have continuous current on the low tension for most of the incandescent lamps and some arc lamps, and they have also the arc lamp distribution over the whole town, lighting the public streets—high-tension continuous current. Nearly the whole of the arc lamps are used with direct current, either on the low-tension system or on the high-tension system, using the same generating stations but separate engines and separate dynamos. The station has 14,000 incandescent lamps of 16 candle-power, and supplying 350 arc lamps in the streets. The arc lamps were what is called 2,000 candle-power—that is about 500. They have been using Edison's rigid mains, jointed, but they have introduced largely wire mains. For the arc lamps, however, and only for the arc lamps, they use overhead wires. Coming back to the general question, if they had to light a large house like Winchester House, with a great number of rooms, it would not be necessary to have more than one transformer under the Metropolitan system in the house. There would be no difficulty whatever with working it with one transformer, but he did not say it would be the best way. He did not like to say what was the greatest load of lamp supply one transformer could safely carry. He did not think any limit had been proved. They had experimented a great deal in America, and the result of their experience was that they do not make transformers larger than 40 lights of 16-candles.

Cross-examined by Mr. MOULTON: He had been asked by the Vestry of Paddington to advise them on the subject of electric lighting. The plan which he was proposing that the Paddington Vestry should adopt was to burn their dustbin refuse in properly designed furnaces to get up steam. The principal difficulty in the way of doing that was that the dust was always coming in during the day and the burning of it would be all during the night. It was most desirable to get some means of burning the refuse both day and night, and this was, he might mention, the principal object that made him determine to put down secondary batteries as the first enlargement of the plant if the plan was gone on with.

Cross-examined by Mr. WILKINS: He did not think any experience had been had with working rigid mains with high tension current, and to work a rigid main, concentric or otherwise, on a high tension would be an experiment. On the low-tension rigid mains the joint was always the weak part, and the difficulty of making a secure joint was enormously increased by the tension of the current. He did not think there was any difficulty which could not be got over in connecting the service main with the house from a rigid main, but the chief question was that of insulation. He would not like to make the connection while there was a high-tension current in it.

Examined by Captain CARDEW: He would have no objection to putting the secondary to earth in the alternating current transformers, and he thought it would assist the safe working. If he had absolute control he thought he could work to a 1½ per cent. variation of pressure. The fact that a concentric main was being used would not increase in any way the danger of making a connection to a house circuit from a distributing main while it was charged—it was not the danger, it was the impossibility. He was aware there were larger transformers in existence than 40-light transformers.

Mr. ALEXANDER SIEMENS, examined by Mr. CRIPPS, stated that he was Vice-President of the Institute of Electrical Engineers, and that he had had large experience as an electrical engineer both abroad and in this country. His experience extended to Berlin, Moscow, Darmstadt, Munich, and Eberfeldt. In Berlin the system now proposed by the Metropolitan Company had been adopted. There were several small stations, comparatively small; they intend putting up a few more, and eventually to connect all of them. At St. Petersburg, which he did not know personally, they had merely a central station with the three-conductor system direct current. The first lighting started from barges on the Neva moored along the quay, but it was now on land in the usual way, near the places where the lights were used. At Moscow the system was the same as at St. Petersburg. Darmstadt is just being put up. There they have got a system of batteries, but they are employed in a totally different way from the E.P.S. system. It is a four-wire system. At Munich there are three conductors. At Eberfeldt there are also three conductors, and it has the peculiarity that all three conductors are in one concentric cable.

Cross-examined by Mr. SHIRESS WILL: In Berlin the installations are very near together—about half a mile apart, or something of that sort. It was in the busiest part of the city where the lights were all required. He did not attach much importance to the talk about noise, vibration, and smoke, because at the Savoy Theatre there was an installation with 1,200 lights, and nobody had heard anything of it at all. In Berlin he did not believe there had been many serious complaints, and the Government was very fatherly there and would have stopped them.

Cross-examined by Mr. RUSSELL GRIFFITHS: He was a member of the firm which lighted part of the City of London—that is, the Poultry, King-street, King William-street, and London Bridge. They lighted it for one year under contract, and were willing to continue it at the same price. There were six large arc lights and about twenty-eight small ones—the six arc lights were continuous arc lights, each with its own main, and the other lights were alternate-current lights in seven series. The mains for both were copper wires insulated with gutta-percha and covered with tape and drawn into iron pipes, partly under the footway and partly in the street. There were connecting boxes which could be used as testing-boxes at each lamp-post.

Examined by Captain CARDEW: With reference to the question of making connection with the mains while charged, one danger would be that of a short-circuit occurring, and thereby perhaps damaging the mains or setting off the fuses, which danger was equally apparent either with high or low tension, and he would never recommend such an operation to be done practically.

Sir WILLIAM THOMSON, examined by Mr. C. A. CRIPPS, said that he was aware of the system which the Metropolitan Company propose for the supply of electricity in London, and he considered that system as good as any other or the best which could be adopted for the supply of London. The system of alternate-currents and transformers was capable, in his opinion, of being used by means of central stations in crowded places. The highest pressure that he had known used in mains was that of the 2,400 volts at the Grosvenor Gallery installation.

Examined by Mr. GRAHAM: He was familiar with the working of the system proposed by the London Company, and had seen the works at Deptford. He thought there was great but not insuperable difficulty in going up from 2,400 volts pressure to 10,000; it was a very great experiment. He thought there would be difficulty with the insulation, but believed it could be practically carried out. He thought there was no more danger from a high potential than there was from a circular saw. Lighting by the direct current system had a long start of the alternating system—more than three years—he had had it himself since 1881.

Cross-examined by Mr. MOULTON: Difficulty had always been found by telegraph engineers in making permanent good joints under ground, but not insuperable difficulty. Defects sometimes did not show themselves at once, but developed gradually, and such defect would be greatly increased by great pressure. The circular saw, although safe in a workshop, might not be a good thing in the nursery, and it was exceedingly important to keep these high pressures as far away from the consumer as possible.

Cross-examined by Mr. SHIRESS WILL: The mains which had been produced here and which he now saw could, in his opinion, be used for 100,000 lights of 10 candle-power.

Major MARINDIN: Without any insulation outside?

Sir WILLIAM THOMSON said he understood the outside sheath would be insulated. They could be used perfectly with the outside sheath laid underground, but it would make a great disturbance in the neighbourhood. The insulation would have to be done at considerable cost. He recognised the propriety of having some reserve producing power.

Cross-examined by Mr. WALLACE: He could not give an opinion as to the tests that had been made of the high pressure spoken of without having seen them. He had not advised the company in the matter, he had simply supplied an electrometer to work up to 80,000 volts. He thought it better to have reserve power under a day's supply, but something to be effective in the case of stoppage—perhaps 12 hours' supply would suffice for a useful storage reserve.

Cross-examined by Mr. RUSSELL GRIFFITHS: He did not anticipate any disturbance to telegraphic or telephonic wires with the outside tube properly insulated. He thought an insulation sufficient for 200 or 300 volts would be more than ample. He had not thought of what material that insulation should be; it depended on how the mains were laid. If they were laid in an iron pipe, and water was not allowed to lodge in it, he did not think that lead would be necessary round the outside.

Examined by Captain CARDEW: He would recommend the earthing at the Deptford end and earthing of the supply wire in every house, one of the two supply low-tension wires in every house. With reference to the minimum amount of insulation at the mains, his opinion was that as long as the total leakage did not amount to sufficient to cause interference with telephones the amount of insulation would be enough; in fact, if there were no telegraphs and no telephones to be considered the main might be laid in the earth without any insulation at all—it would work perfectly well.

Mr. JAMES SPENCER BALFOUR, M.P. (examined by Mr. LYTTLETON) said he was a director of the Metropolitan Electric Supply Corporation. He thought the capital that had been subscribed was amply sufficient for the present purposes, but he contemplated a further extension of the company in the future, and it was so stated in the prospectus. The shareholders took the shares upon that basis. He had been extremely anxious that they should apply in the first instance only for so much capital as was

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sufficient to obtain a perfectly complete experiment. He was the owner of a considerable amount of property in the south of London, and a great many applications came from that quarter. He anticipated from Streatham and Brixton a large number of applications for the electric light. He did not think there would be any difficulty in getting a large addition to their present capital (£500,000). The original capital was largely over-applied for. If they had sought for a million they would have got it.

Cross-examined by Mr. WALLACE: He had not entered into any agreement with the House-to-House Electric Supply Company, nor was he about to enter into any agreement or working arrangement of any kind. The public subscribed the capital. In the prospectus produced it was stated that they had applied for Parliamentary powers for a Provisional Order. The Provisional Order was not confirmed, but we obtained it.

Mr. MOULTON cross-examined as to statements in the prospectus affecting the supply of electricity in the parishes of St. James, Westminster, and St. Martin's-in-the-Fields.

Cross-examined by Mr. YOUNG, the witness stated that the whole of the £500,000 capital was subscribed, the amount of the commitments of which was £350,000 at present, but all of that was not expended—it was in course of expenditure. Perhaps £100,000 had been actually expended, leaving about £230,000 or £250,000 unexpended out of the commitments. The free capital was about £150,000.

Sir WILLIAM THOMSON said he desired to say that with reference to the answer he gave in which he said that he thought one of the secondary supply wires ought in every case to be connected with the earth, it was an opinion formed after very careful consideration. Now that the pressure was proposed to be very much higher, it would be dangerous to life, or at all events it would produce a very inconvenient shock, if the metal work of the lamps was at any such potential as 1,000 volts difference from the earth. A person standing on a wet floor or a person in the act of turning a water tap might at some time put his hand on some of the lamp fittings and get a shock that might be very considerable. The larger the transformer the larger its electro-static capacity, and the greater would be the amount of the shock. Such an accident as this produces no danger whatever of fire. His proposal was simply to connect one of the supply wires to the water pipes, to let this be done through a resistance of 10,000 ohms, or 5,000 ohms, and the result would be even in case of a dead earth on the supply wire. The greatest amount of current that could pass would be a few milliamperes. The insisting of that proposal would be no inconvenience to anybody, and people would have the satisfaction of knowing that they have only 100 volts potential in their houses.

Mr. EDWARD STOPFORD CLAREMONT, examined by Mr. C. A. CRIPPS, said he was manager of the Metropolitan Electric Supply Company. The machinery that would be used for the various stations would be perfectly noiseless, and there would not be any risk of nuisances arising from noise, smoke, or vibration. The first station is Whitehall Court, a perfectly isolated position, then Sardinia-street, a very low locality at the back of Lincoln's Inn-fields. Rathbone Place has been running for 18 months, and has never been threatened with an injunction. For the Manchester-square station they held a license from the Duke of Portland, authorising its erection. At the last station, Eccleston-place, there are two nuisances already existing, one a chimney, which they propose to utilise, erected 16 years ago, the other the Metropolitan Railway, the vibration from which must be much greater than could possibly be caused by the engines of the station. The estimate for laying down the mains was £1,250 to £1,350 per mile, which included the cost of opening up the streets, cables, and everything required. The number of applications for lamps already received was—Marylebone, 19,720; St. James's, 6,350; St. George's, Hanover-square, 1,370; City, 1,340; St. Martin's, 2,460; and the Strand, 3,140, making a gross total of 44,660. That did not include the lights they are supplying now.

The witness was cross-examined on behalf of the various companies and vestries interested.

Major MARINDIN said he had received intimation that it would be convenient for counsel that the inquiry should proceed on Wednesday and Saturday this week, and on Monday, Tuesday, Wednesday, and Thursday next week, and this was arranged to be done.

WEDNESDAY, APRIL 10.—SIXTH DAY.

Mr. CRIPPS commenced the day's proceedings by reading copious extracts from a draft agreement between the Metropolitan Electric Supply Company and the Strand District Board of Works. He stated that the agreement had not been actually dated; at the present time there was still some formality to be gone through, but he would hand in the undated printed draft as it stood.

Mr. EDWARD STOPFORD CLAREMONT, recalled, in reply to Mr. PEMBER, stated that except as a point of honourable understanding the agreement was of no validity whatever. Its terms differed slightly in some particulars from the Provisional Order.

Mr. BONNOR MAURICE stated that on behalf of the Metropolitan Electric Company he drew up the agreement.

Cross-examined by Mr. PEMBER: He had no doubt if the order was confirmed by Parliament it would be executed. He did not know whether the agreement would be drafted into the order or how that would be, but the effect would be that the agreement would be carried into effect. According to the second schedule of the agreement, the undertakers shall be entitled to charge 6s. 8d. per unit, but shall not be required to supply in any less quantity than two units per quarter. In the order the consumer is bound to take 15 units as a minimum for £5. 10s., and for every unit above that the company may charge him 6s. 8d. per unit. That minimising of the quantity may be a considerable concession, but on the other hand it may result in getting a much larger quantity taken. He could hardly say whether he would like to do a business with many people who only took two units a quarter. He could deal rather with the construction of the agreement than with the policy of it. There is a clause in the agreement that where the supply is "by lamps" the undertaker shall be entitled to charge for each light for a continuous supply at the rate of 30s. per annum, and for an intermittent supply during 18 hours at the rate of 25s. per annum. The only such provision in the order is a clause to the effect that they may charge a sum per lamp. Under the agreement they were put under a penalty of £100 for every default and a further sum of £5 a day during the continuance of such default.

Cross-examined by Mr. HUNTER: We make the concessions in the agreement with the Strand Board of Works, having regard to the peculiar nature of the Strand. We bind ourselves under clause 4 of the agreement to lay down and complete distributing mains within a period of eighteen months from the date of the agreement so far as the streets are coloured green on the map. Supposing a consumer situate half a mile from the nearest available source of supply, he must, before being entitled to a supply, along with others, provide 20 per cent. of the cost of connecting his premises with that supply.

Cross-examined by Mr. RUSSELL GRIFFITHS: Our company admits, as shown by the agreement, that there may be special reasons requiring different conditions for different districts. The amendment in the Provisional Order as to overhead wires is the same as in the London Electricity Supply Company's Order, word for word, but we shall not obtain by it any rights as to overhead wires; it would not give us any rights that we have not now. Taking the case as put, that having the right under the order to lay mains underground, and that the company lighted house A, and across the street lighted house B, they might, under agreement, use overhead wires, because those wires would not be laid under the order. They might supply, partly under their own Provisional Order and partly under their common law right; he did not say they claimed the right, but it seemed possible—it was arguable that they had a right to go overhead. Mr. Claremont, their manager, had said that in narrow streets they might be obliged to run wires overhead.

Cross-examined by Mr. H. C. JONES: They would furnish the Strand district under the agreement from the Sardinia-street station—that station was primarily appropriated to lighting the Strand. The station would be ample to supply also the St. Giles's district, but he believed there were objections to extending the provisions of the agreement to that district. However that was a question of policy which he was not able to answer. He was only there to answer questions with regard to the form of agreement.

Major MARINDIN: I think Mr. Cripps told me there was no objection on the part of the company to extend the agreement to anybody else.

Mr. C. A. CRIPPS: That is so. You may take that as the policy of the company.

Cross-examined by Mr. CRIPPS: He obtained instructions from his directors to negotiate an agreement with the Strand Board upon the lines suggested in a letter written by them dated 23rd November. He was instructed generally to make every effort to meet the views of the Board as far as their requirements seemed reasonable. He would not go so far as to say that the agreement was equivalent to a kind of partnership between the company and the District Board with regard to electric lighting in the district.

Re-examined by Mr. C. A. CRIPPS: As regards the steets coloured green there was no doubt they would have to lay their mains along and supply them; therefore, in submitting to compulsory powers as regards those streets, it was merely in conformity with what he considered would be the necessary course of the company's business. The intention, he believed, was to lay down those mains at once as soon as power was obtained. Outside the green-coloured district they would be bound by a requisition of six owners or occupiers; under the agreement they were to be given for the purpose of laying their mains a space 12 inches wide and 6 inches deep beneath the present surface of the pavement.

Mr. MOULTON, Q.C., in addressing the Inspector on behalf of the Chelsea Electricity Supply Company, said it was not only his own desire but the desire of the representatives of all the Electric Lighting Companies, who propose to give a continuous supply and to do all in their power to shorten the Inquiry, and therefore he would as far as possible open the general case with regard to direct supply, and especially with reference to the use of storage batteries.

Major MARINDIN: Do you mean to say on that point you are speaking for all the companies?

Mr. MOULTON said: For all the companies that propose to use the direct supply, simply so far as he was dealing with the scientific aspects of the question. He was also instructed by the Telephone Company, but he was not going to refer to them except to give notice of the fact and to say that at the end of the inquiry it might be that those clients would wish to put some evidence before the inspector bearing especially upon some of the statements made by the witnesses for the Metropolitan and the London Companies. His clients were of opinion that the steps taken by the Board of Trade in 1883 and 1884—steps taken after very long and patient consideration and examination of the subject—should not be departed from. He did not say that knowledge and experience had not increased—he would be very sorry if that were the case—but the bearing of electrical knowledge on the practical problem with which these electrical orders were intended to deal had only justified, only strengthened the grounds for the conclusions to which the Board of Trade then came. The Act of 1888, which altered the Act of 1882, although not an Act with which in all respects he could sympathise, was certainly a great concession to electric lighting companies in general, and it admitted that the legislation of 1882 was in error in the unfavourable character of the terms it gave to electric lighting undertakings, so far at all events as the period of concession was concerned. The company that he immediately represented at this moment—the Chelsea—was, he thought, the only company which was bold enough to obtain and try to carry out the order under the terms of the 1882 Act; but it had this clause in the model order which was in addition—and a very reasonable addition—that, supposing any general Act was passed

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a little later making the terms as to length of concession more favourable to electric lighting undertakings, it should have the benefit of it. In September, 1886, it obtained those powers, and, as they had heard, until the 1888 Act was passed it was not able to set to work because it could not get its capital, but as soon as the 1888 Act was passed it obtained its capital and commenced to work. It had been foreshadowed by the evidence that for house-to-house lighting through a district of comparatively small area the direct supply was the cheapest, best, and most convenient form. It was best to the consumer, most easily capable of being made regular and dependable, and the one which was farthest removed from the risk of extinction. The transformer system had, no doubt, an enormous advantage in dealing with a straggling supply. Distance from the generating source—distance between the different distributing centres—was a matter of comparatively little moment. That which it gives to the consumer is far less valuable, the dangers which attend it are far greater, and its liability to immediate extinction is incurable; but the distance between the centres either of distribution or generation is a matter quite a trifle. Therefore all that those who are supporting the transformer system want is power over a large area. Given power over a huge area, what they will do is—occupy those places in which they can give electric light most cheaply, which were the cream of the whole, and in that way whether Parliament gives them a monopoly or not is a matter of very little concern to them. If they can only get possession of the good bits and can work those good bits on the favourable terms that good bits can be worked, it will not be easy to dispossess them from those strongholds by giving competitive powers to companies who would come in on no more favourable terms.

With reference to the price, he said that with even moderate supervision from the Board of Trade, from the local authority, and from the public, no electrical company could make exorbitant profits. They would not dare to do so, because if it did not reduce its price so that its profits were fair there would be a pressure of public opinion and a possibility of punitive competition. What his clients wished and were prepared to do, was the direct supply in an area, and what they were here for was this: that kind of dealing which the Board of Trade had thought fairest to everybody. The companies he represented were prepared to take clauses which would compel them to do their work, and no better clauses could be found than those in the model order. They were prepared to take their orders under the distinct understanding that if they did not do their duty others should be allowed to come in; but what they did say was, leave us time—give each company an area by itself, an area moderate in size that it could do thoroughly—let each company show how well it could perform those duties—at how reasonable a price it could give a good service to the public, but let it do that unhampered. Let it have a fair field to do that, and in a year or two, when these things were no longer in project but in actual working, they would then see what system was the best, and whatever system was the best then the others would have to adopt it or let competitors in.

It was admitted that the direct supply alone was capable of being used with equal advantage for lighting, but with infinitely greater advantage over motive power. What Mr. Ferranti had in his pocket in the way of motors which would work with alternating currents he did not know. Mr. Ferranti declined to take it out of his pocket. He (Mr. Moulton) could not pick Mr. Ferranti's pocket—that was beyond even the privileges of counsel; but nothing was more remarkable than the way in which inventors had solved just *the* problem of the universe that had never been solved before. He heard these things with deep sympathy. He did not say anything against this patent, but he looked on, should he say puppy patents, while still in their puppydom as things certainly not to be invested in. Now with regard to cheapness. The properties that make it so much the best for the public by reason of there being storage in it and connected with it are the very reasons for its being cheaper. The moment you introduce the power of storing electricity the whole of the curves of demand need not be provided for in the generating plant. Whether you supply entirely from storage batteries or not, you can be using stores that have been piled up during the day, and by combining direct supply with storage you can have all your machines working during those hours. You can have all your batteries discharging directly during those hours, and the consequence is you can easily meet every demand.

In conclusion, he submitted that what they were asking was a reasonable extension. They had shown a willingness and a capacity for doing what they undertook to do, and doing it practically in a much shorter time than they originally took for it, and he thought if this order was granted they would be able to give a satisfactory, steady, reliable, and safe supply of electricity under circumstances which would not excite nervousness in the minds of any reasonable householder. He thought therefore that the orders he represented were orders which should have not only the approbation of the Board of Trade, but that they should be supported by their influence.

Mr. ROOKES EVELYN CROMPTON, re-called, examined by Mr. MOULTON, said he was managing director of Crompton and Co., and from 1882 had given great attention to designs for central stations. Had designed and carried out installations at Vienna, Le Mans, and a central station at Kensington, which had all worked with the greatest success. He was of opinion that engines could not be so economically worked with the transformer system as with the direct system. Nothing increased the wear and tear of engines so much as running them lightly loaded for lengthened periods. Certain well-known makers of engines absolutely forbid it—Mr. Willans absolutely forbids his engines to be run with no load. The best unit area for supply he thought would be about half a square mile from each generating station, each generating station supplying four distributing stations if they could be easily obtained. The cost of carrying a main sufficient for the distribution of about half a square mile for 2,000 yards—that would be the average distance from a wharf site—would be about £5,000, added on to the capital charge.

The Inquiry was adjourned to Saturday next.

OBITUARY.

J. W. FULLER.

It is with great regret we have to record the death of Mr. J. W. Fuller, on the 8th instant, after a long and painful illness, at the comparatively early age of 46. Mr. Fuller's connection with telegraphy dates from a very early period, he having been connected with various telegraph companies for over thirty years, twenty-five of which were spent in the service of submarine cable companies. He joined the Electric and International Telegraph Company soon after its formation, and proceeded afterwards to one of the Mediterranean companies' stations at Benghazi.

On the formation of the Eastern Extension Company he was appointed General Manager at Singapore, and actively superintended the establishment and working of that Company's stations in the Far East. On his return from Singapore in 1874, he was engaged as traffic manager in The Direct United States Cable Company, then being established, and he there organised the traffic and staff arrangements. When that Company passed under the chairmanship of Sir John Pender, Mr. Fuller, in addition to his former duties, was made the Secretary of the Company. In this position he was actively engaged until in the early part of 1887 illness necessitated his retirement. He was a member of the Society of Telegraph-Engineers and Electricians. On behalf of the Direct Cable Company he attended both the London and Berlin Telegraph Conferences. His genial manner and obliging disposition won for him many friends who will regret the premature termination of an active and promising career.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, April 12th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Electrical Measuring Instruments: Their Properties and Calibration." By SAMUEL JOYCE, jun., Stud.Inst.C.E.

ROYAL INSTITUTION.

9 p.m. Evening Discourse. "Iridescent Crystals." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

SATURDAY, April 13th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "Experimental Optics (Polarisation: Wave Theory)." By the Right Hon. Lord RAYLEIGH, M.A., F.R.S.

PHYSICAL SOCIETY.

3 p.m. "A Lecture Experiment Illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel," and "An Experiment Showing an Effect of Light on Magnetism." By SHELFORD BIDWELL, F.R.S. "On the Dark Flash seen in some Lightning Photographs." By G. M. WHIPPLE. "On Quartz as an Insulator." By C. V. BOYS, F.R.S. "On a Refraction Goniometer." By A. P. TROTTER. "Apparatus to Illustrate Crystal Forms." By Prof. R. J. ANDREWS, M.D.

MONDAY, April 15th.

SOCIETY OF ARTS.

8 p.m. Cantor Lecture V., 4. "Instruments for the Measurement of Radiant Heat." By C. V. BOYS, F.R.S.

TUESDAY, April 16th.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "Armour for Ships." By Sir NATHANIEL BARNABY, K.C.B.

ROYAL VICTORIA HALL.

8:30 p.m. Lecture. "Electric Tram-cars." By Dr. J. A. FLEMING.

WEDNESDAY, April 17th.

ROYAL METEOROLOGICAL SOCIETY.

7 p.m. Ordinary Meeting. Papers to be read "On the Deaths Caused by Lightning in England and Wales from 1852 to 1880." By ROBERT LAWSON, F.R.Met.Soc. "The Diurnal Range of the Barometer in Great Britain and Ireland." By F. C. BAYARD, F.R.Met.Soc. "Note on a Working Model of the Gulf Stream." By A. W. CLAYDEN, F.R.Met.Soc.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 4 p.m.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 641
Experimental Lightning Conductors 646
Reviews 647
The Board of Trade Inquiry on the London Electric Light Provisional Orders 647
Obituary—
J. W. Fuller 653
Meetings of Scientific Societies. 653
Nature on "Practical Men and Electrical Units" 654
The Fritsche "Wheel" Dynamo. Illustrated 655
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Continued 657
Report to the Vestry of Paddington on the Electric Lighting of the Parish. By Prof. Geo. Forbes, F.R.S. 658
The Van Depoele System of Electric Railway. Illustrated 660
American Notes 661
Notes from Paris 662
Correspondence—
Deflection of an Electro-Magnetic Wave by Motion of the Medium—Oliver Heaviside. Illustrated 663
Correspondence—*Continued.*
The Wiring of Houses—Geo. T. Pardoe 664
Legal Intelligence—
United Telephone Company *v.* Siemens Brothers and Co. 664
Durtnall *versus* Shippey Brothers 664
Cardiff Electric Engineering Company 664
Companies' Meetings, &c.—
The Eastern Extension, Australasia and China Telegraph Company (Limited) 664
Electrical Power Storage Company (Limited) 665
Montevidean and Brazilian Telegraph Company (Limited) 667
The Telephone Company of Ireland (Limited) 667
The Electrical Automatic Delivery Box Company (Limited) 669
Reuter's Telegram Company (Limited) 669
New Companies Registered 669
City Notes, &c. 669
Companies' Share List 670

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GOOD FRIDAY NOTICE.

In Good Friday week "THE ELECTRICIAN" will be published on Thursday morning (April 18th), instead of on Friday (April 19th).

Correspondence, Business Notices and Advertisements for this issue must reach the Publishing Office, 1, SALISBURY-COURT, LONDON, E.C., not later than Wednesday morning.

NATURE ON "PRACTICAL MEN AND ELECTRICAL UNITS."

When, at the Bath meeting of the British Association, six months ago, the respective merits of the "practical man" and of the devotee of pure science became the theme of a somewhat unseemly and wholly profitless controversy, we ventured to remark that practical men were not entitled on every occasion to assume superior airs or invariably to speak of the mere theorist in tones of pitying contempt. To this opinion we still hold, but circumstances have now arisen in which it seems to be equally our duty to maintain that when a journal which exclusively represents the school of "pure science" discusses the status of the men who (to use its own words) "fulfil the useful function of putting together machines [*i.e.*, dynamos] they do not understand," the mood of intellectual scorn is after all equally inappropriate. Before entering further upon the argument we must briefly explain the causes which have given rise to this outburst of *Nature*. It appears (for we know absolutely nothing of the matter save what we find in the article before us) that a gentleman "who calls himself a practical man," and who is further described as "representing an important firm" of electrical engineers, recently went down into the provinces, and there addressed the members of an Institute "connected with one of

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the most important of our national industries." This being the case, we can scarcely be far wrong if we surmise that his errand was really of a commercial character. It is, in fact, clear enough, from the quotations made by our contemporary, that the object of the expedition was not to instruct the members of the Institute in the science of electricity, but to induce them to employ electrical machinery in the industry with which they were associated. With this laudable purpose—however derogatory in the eyes of our critic—the speaker very reasonably laid stress upon the ease with which his auditors might learn what little it was necessary to know in order to deal in ordinary practice with electrical machinery. He told them how, by the aid of an ammeter and a voltmeter, electrical energy might be measured and expressed in units with which they were already familiar. But this is more than our captious critic can stand. "Do the supporters of the practical man," he asks, "think that this easy measurement, this simple connection, came by accident?"—an interrogation which is very little to the point, and seems to us to border upon the absurd.

We are nevertheless bound to admit that our practical man did not altogether succeed in handling his electrical units so as to be at once simple and accurate; in fact, he more than once blundered into inaccuracies of expression which we have not the slightest inclination to excuse. Here we must abandon him to the tender mercies of his critic, whose denunciations are of a wholly remorseless character. To talk of "watts per minute," or to state that "one watt is equal to 4·4 foot-pounds," are solecisms for which we can only express surprise and regret that an electrician should have been guilty. We may, however, remark that to the man whose proper sphere is in the drawing-office or the testing-room, the task of presenting electrical questions to an audience almost wholly ignorant of the subject, and yet deeply interested in its commercial possibilities, can scarcely be esteemed an easy one; in fact, it demands qualifications of a very special order. Had our friend—whoever he may chance to be—been aware that his effort would achieve the distinction of a lengthy review in the columns of *Nature*, he would probably have been a little more careful with his electrical units. But, as we have already said, for his carelessness he deserves rebuke. We are willing, and indeed anxious, to endorse our contemporary's dictum that, "if men are to be 'practical' and nothing else they must at all events be accurate. If they are to use formulæ which they do not understand, they must at all events know how to use them correctly."

But our readers will scarcely fail to notice in the words just quoted—and this is why we deem it necessary to take up the cudgels in defence—that our contemporary conveys the opinion that electrical engineers (and here the reference is more particularly to those engaged in the design of dynamos and motors), *as a class*, are practical "and nothing else," and are accustomed to use formulæ which they do not understand. This is a suggestion which is still more unmistakable in the remainder of the article, and it is one which we wholly repudiate. Our acquaintance with the class referred to—and it must be remembered that the class is a limited one—is probably both more extended and more intimate than that of our contemporary, and we have no hesitation in asserting that from a purely scientific standpoint their opinions are, *as a class*, entitled to the fullest and most respectful consideration. In intellectual calibre, and in the possession of a genuine regard for and a *scientific* interest in their profession, these men will bear comparison with any similar class in this or any other country. These assertions would, we are quite certain, be borne out by the opinion of those gentlemen of professorial dignity who in London come most in contact with them, and who by the way, never exhibit that tone of superior virtue which is so prominent in the article in question.

The reason which chiefly seems to have led the critic into the mistaken notion that electrical engineers are a set o unmitigated Philistines arises from the interpretation which he chooses to put upon a passage in the address referred to—certainly not altogether a happy one—to the effect that "we do not want to know what electricity is but what it will do." The critic takes it for granted that this observation affords a clue t the attitude of electrical engineers in general towards pure science. As a matter of fact, we unhesitatingly deny that it does anything of the sort. We are, moreover, strongly inclined to believe that its originator never intended any such interpretation to be put upon his words. Remembering the circumstances under which they were spoken, it is equally natural to suppose that the phrase quoted was nothing more than a rhetorical way of expressing the fact that for the purpose immediately in view it was not necessary for his audience to enter upon a study of electrical theory; they need not trouble themselves with the inquiry what electricity is, it would be sufficient if they became acquainted with "what it will do." Thus this supposed confession of a brutal utilitarianism sublimes into a mere commonplace of commercial life.

As a matter of fact, we believe that the antagonism betwixt the exponents of theory and of practice is confined to a far more limited number of disputants on either side than a perusal of our contemporary's article would lead one to imagine. The controversy which broke out six months ago had, we thought and hoped, already died away, and we are sorry that our contemporary should—on the very slender basis which we have indicated—have thought proper to fan the smouldering embers. As a matter of fact, in London circles at any rate, the leading men on either side are too well acquainted with one another, and they have too much good sense, to be at all anxious for the continuance of a controversy which is equally barren and factitious. At the same time, we felt that we could not allow to pass uncontradicted so gross a misrepresentation of the views of a class of men of which the profession has every reason to be proud.

THE FRITSCHE "WHEEL" DYNAMO.

The dynamo which we illustrate below has been brought out by Messrs. Fritsche and Pischon, of Berlin, as a low-speed multipolar machine, and some description of it has already appeared in our Berlin correspondent's letter of February 25. Most if not all such dynamos are really only several separate machines—as many as there are pairs of poles—joined in parallel, and to obtain the same E.M.F. as in a similar double pole machine the peripheral speed must be about the same. In the Fritsche winding, however many pairs of poles there are there is only one circuit in the armature—one, that is, in the same sense as there is one only in the ordinary Gramme ring or Siemens drum. The effect of all the poles is therefore obtained in series, and the speed is proportionately low.

In his patent specification (one of the most readable we have ever come across), Herr Fritsche gives the whole evolution of the winding, which we may here shortly reproduce. He first takes an ordinary Siemens drum, and flattens it out (Fig. 1)—a proceeding, *en passant*, which makes it much clearer than the ordinary perspective drawing given in text-books, and which future writers might do well to follow.

The shaded portions represent the pole-pieces; the straight lines, both full and dotted, the active wire on the surface of the drum. The idle cross-wires at the back end of the armature may then be represented by the diagonal lines at the top, while the connections to the commutator segments are at I., II., &c. The wires in the figure are all numbered, so that the circuit may be easily traced.

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Herr Fritsche now removes the parallelogram A B C D, representing the active wire in the Siemens winding, and brings the remaining upper and lower "idle" wires together, alters the shape of the pole pieces, and obtains the winding shown

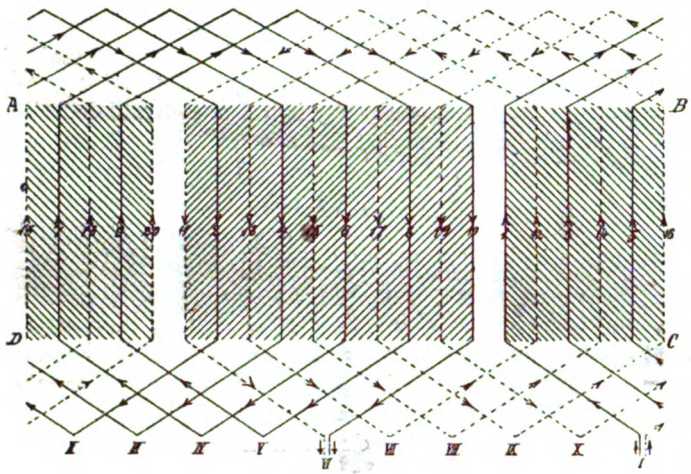

Fig. 1.

in Fig 2. In this form, however, the bends in the middle of each conductor would make it unpractical mechanically. Looking, however, at the point where the bends in two conductors are superposed, *e.g.*, 1 and 12, 3 and 14, 5 and 16, etc., we find, taking the first pair, that the current in the lower part of 12 is in the same direction as in the upper part of 1, while that in the lower part of 1 is in the same as in the upper part of 12; therefore, instead of bending each wire back on itself we can cut it and join the lower end of 12 to the upper end of 1, and *vice versâ*, and the same with all the other pairs. We thus arrive at the winding shown in Fig. 3, giving the equivalent of a Siemens winding composed only of what *was* the idle wire, and built up of plain, perfectly straight strips (except that there is a slight circular bend to form a round drum). For this form

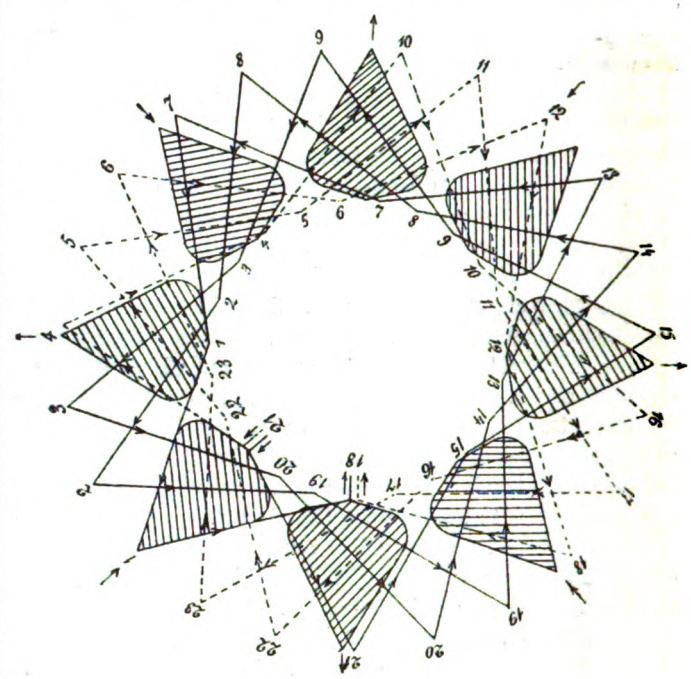

Fig. 6.

Herr Fritsche suggests the name of "wave-winding." Let us now apply these two windings to multipolar machines. Fig. 2 will extend to Fig. 4, giving no greater E.M.F. (*cæteris paribus*) than Fig. 1, and will require as many pairs of brushes as there are pairs of poles. Fig. 3, on the other hand, when extended to Fig. 5, still requires only one pair of brushes, however many pairs of poles there are, and the E.M.F. is increased in the same proportion.

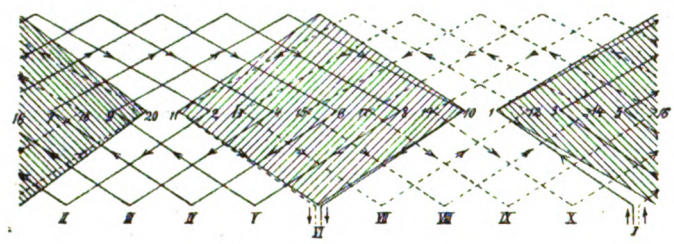

Fig. 2.

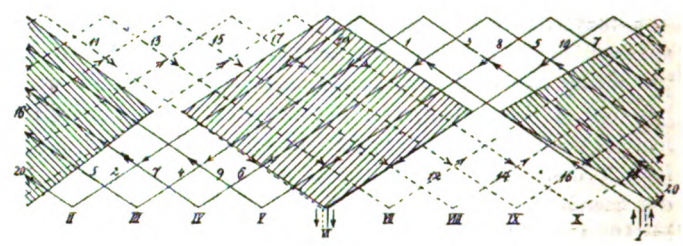

Fig. 3.

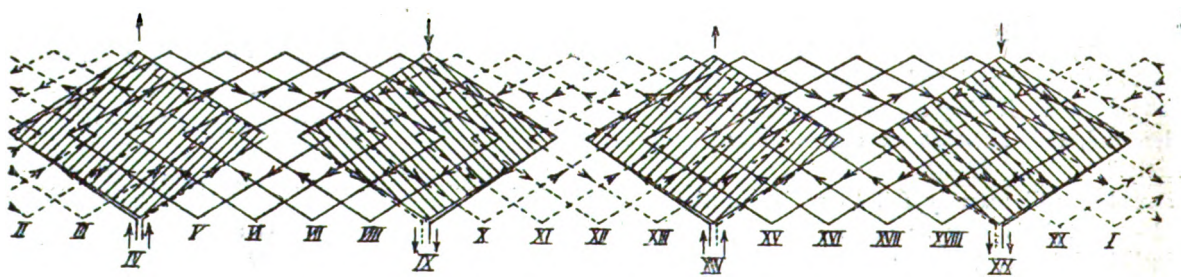

Fig. 4.

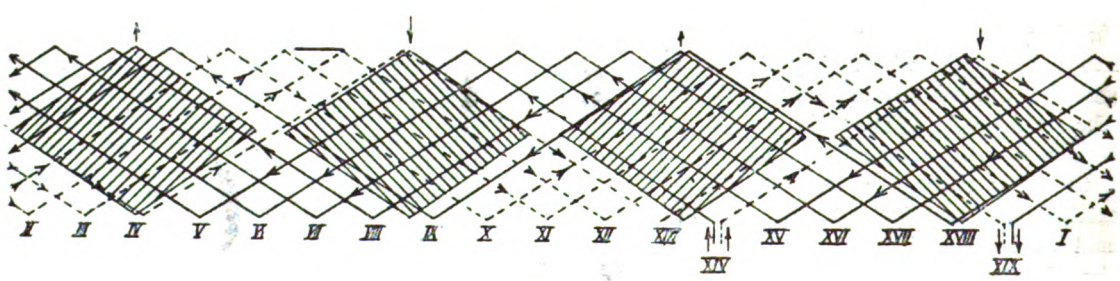

Fig. 5.

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We have so far considered the winding as if it were a flat strip to be rolled up into a drum, but there is obviously no reason why the two ends should not be bent round *in the plane of the paper* until they touch, thus giving the disc armature shown in Fig. 6.

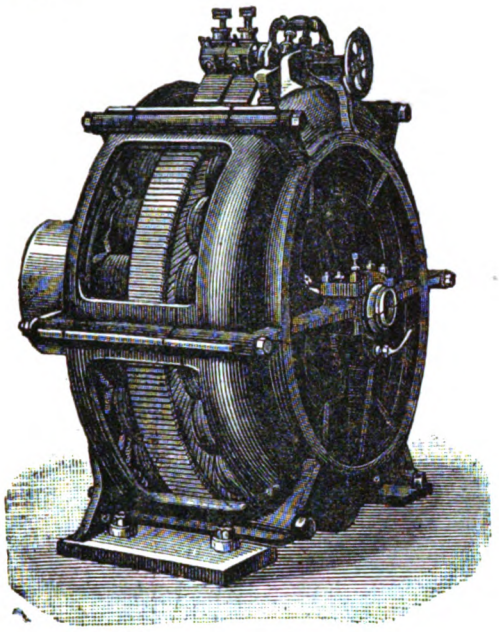

FIG. 7.

The drum form has, we are informed, been used with good results, but at the present moment the disc armature is of more interest as exemplified in a type of machine recently put in the market. This is shown in Figs. 7 and 8, and quite apart from the winding is remarkable from the fact that the armature is formed of wrought iron bars, with air insulation only, there being no core of any kind. The inventor claims that, owing to the use of iron instead of copper allowing greater heating, and to the very perfect ventilation due to the absence of all solid insulation, a large current density can be used—in fact, that the armature could be run almost red hot. A low magnetic resistance is also attained, and Foucault currents are

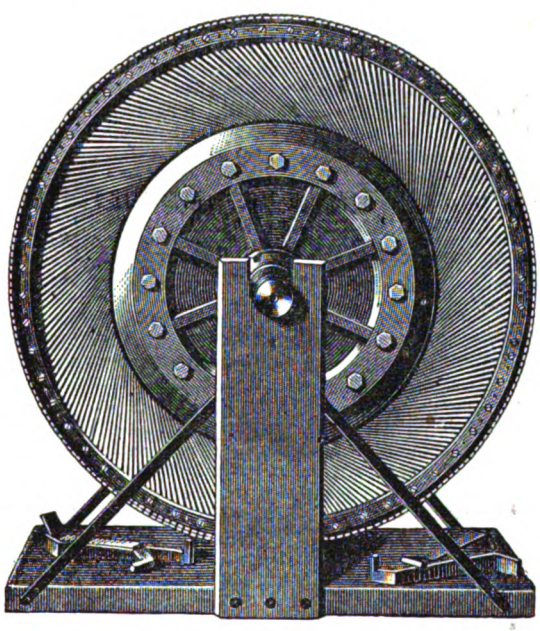

FIG. 8.

diminished. But while all this may be admitted, yet, when it is considered how small a proportion the cost of the copper in the armature of a good modern dynamo bears to the total cost of the machine, we take leave to doubt whether the employment of iron for the armature conductor is strictly defensible.

The following table gives some further details as to the machines actually constructed :—

Speed.	Current.	Output.	Armature Resistance.	Weight, cwt.	Weight, cwt. per h.p.
180	50	5,500	—	28	3·8
160	85	9,400	·06	42	3·3
160	130	14,300	·04	56	2·9
140	200	22,000	·025	76	2·6
140	330	26,300	·0138	102	2·9
140	540	59,400	—	140	1·75

E.M.F. in all sizes, 110 volts.

We may remind our readers that in our issue of March 29 (p. 602) Messrs. Jehl and Rupp claimed to be the inventors of a similar winding. We have some recollection of having received a description of the machine referred to by them about twelve months ago, and probably our reason for withholding it from publication was that the machine did not appear to have been actually built at the time.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION III.—MAGNETIC FIELDS OF COILS AND SOLENOIDS.

(*Continued from page 596.*)

149. *Intensity of Field at the Centre of a Solenoid.*—In the treatment of this subject there is involved the use of a branch of mathematics not frequently understood either by those who are commencing their electrical studies or even by old and tried practitioners. But while it is very serviceable to be able to sum up a series of extremely small quantities by the usual mathematical process, it is very much more important to have a common-sense view of what has to be done to attain the result aimed at. It is a cause of disappointment and dismay to many students who have been carefully following up a subject to find themselves, after much labour spent in trying to understand it, handicapped by a mathematical process which is said to attain the desired result, but of which they do not comprehend the meaning. The said mathematical treatment would be quite out of place in these Letters, and if the result were put down accordingly without any explanation of the process by which it is arrived at, the reader would be no better off than before. Hence, it seems desirable to steer a middle course between these two extremes. But the task so proposed has in it somewhat of the difficulty experienced by Ulysses on his voyage from Troy, when, to save his men from the grasp of Scylla, he ran the risk of getting wrecked in the whirlpools of Charybdis ; and it is possible that in trying to avoid one alternative we may in some way run foul of the other. The student will find, however, that if he gets a common-sense view even of the *manner* of arriving at the result, or clears up any previously foggy ideas on the subject, he will certainly have scored another point to the good.

To fix our ideas, let us suppose a solenoid six centimetres long, wound with five layers of wire, 40 turns to the layer, and therefore making in all 200 complete turns. Let the depth of the winding—that is, the thickness of the five layers, be half a centimetre, and the reel on which the coil is wound 3·5 centimetres diameter ; this makes the *mean* radius (r) of the coil two centimetres. Suppose that a current of three amperes is passed through the wire, it is evident that it circulates 200 times round the bobbin, and the total current passing round the bobbin is therefore $3 \times 200 = 600$ amperes. Although each turn is really in series with the rest, yet if we look at a section lengthwise through the coil the ends of the wires appear like so many separate conductors, each in "parallel" or "multiple arc" with the rest, and the total current is therefore the sum of the currents carried by each conductor, viz., 3×200; or we may regard the winding as equal to $200 \times 3 = 600$ ampere-turns, which may be replaced, without in any way altering the

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field, by a single turn, occupying the same volume as the 200 turns, and carrying 600 amperes. This is the most convenient, and, at the same time, the most accurate way of looking at the action of a solenoid. We shall therefore think only of the total current circulating uniformly *once* round the bobbin and occupying the same space as the winding. Or, putting the same thing in a general form, to which any figures may be applied, let n be the number of turns of wire on the solenoid, and C the current in C.-G.-S. units passed through the wire. Then we can regard this as a current of Cn C.-G.-S. units making one turn round the bobbin. Now it is convenient to consider this single turn or belt of current as divided up into a large number of thin rings of current, because then we can calculate the field produced at the required point by each narrow ring. In short, the expression which was derived in paragraph 145, viz. :—

$$2\pi C \frac{r^2}{R^3},$$

for finding the field in C.-G.-S. units produced at any point on the axis of a ring of mean radius r centimetres, assumes that the current C is in the exact centre of the wire forming the ring. To make this clear, suppose we take a ring of *wire* and a wide flat *ribbon* of copper, which, when bent round, makes a single turn of cylindrical shape, of the same diameter as the ring. Now, although the same current be passed through the single turn of wire and the single cylindrical turn, the field produced by each at their respective centres is not the same; for in the wire the current is concentrated into a narrow space *immediately surrounding* the point where it is required to determine the field, whereas in the wide cylindrical coil the current is spread over the whole cylinder, and it is therefore only a small portion of the current which flows *immediately over* the centre point. Further, it is obvious that the remaining portions of the current which are flowing round parts of the cylinder further and further away from the centre must have less effect in producing field there than would be the case if the whole current was massed together right over the central point, as in a ring of wire. And therefore we can only apply the above expression to rings of wire or coils of several turns whose *breadth* is very small compared to their *diameter*. But it follows that the field produced by the entire cylindrical coil can be estimated by considering its current as divided up into a large number of very narrow, thin rings, the field due to each of which at the required point can be calculated by the above expression, and the several results for each ring so obtained finally added together. This gives the field produced at any required point on the axis due to the current *in every part* of such a cylinder, and is, in fact, the way in which the total field due to a solenoid is calculated. For the whole coil of wire of a solenoid is cylindrical in shape, and we have seen that it may be considered as one turn occupying the same volume, which is therefore also cylindrical.

(To be continued.)

REPORT TO THE VESTRY OF PADDINGTON ON THE ELECTRIC LIGHTING OF THE PARISH.

BY PROF. GEO. FORBES, F.R.S., M.INST.C.E., M.INST.E.E.

Gentlemen,—The report on the electric lighting of Paddington, which I now have the honour to submit, is divided into three parts, each of which I shall consider separately. These are :—

1. The advisability or non-advisability of the Vestry undertaking the lighting of the district themselves.
2. The best scheme for generating and distributing the electric current if the Vestry undertake the work.
3. The cost of laying down and working electric lighting plant.

1.—The Advisability or Non-Advisability of the Vestry Undertaking the Lighting of the District themselves.

. . . Whether the Vestry undertake the public supply of electric light, or leave it in the hands of one or more supply companies, one point ought to be insisted upon, namely, that the whole of the streets should be lighted by means of arc lamps. If this is done, the streets will have at least thirty times as much light as at present, leading to increased comfort, safety, cleanliness, and morality, assisting the police, and raising the rateable value of the parish immediately by attracting new residents.

The question remains whether it is more wise for the Vestry to undertake the work themselves or to put it in the hands of one or more supply companies. On this point public opinion has been divided, but it seems nearly certain that the granting of a concession to one company may cause an objectionable monopoly, whilst the introduction of competition will probably lead to disaster among some of the competitors and disappointment among the consumers. Furthermore, the work might be done by others in a manner that would not be approved by the Vestry. To take one example, neither the local authorities nor the Board of Trade have sufficient power to prevent a supply company from using overhead wires. The Board of Trade are actually going so far as to virtually give their authorisation to such overhead wires, and the Vestry must recognise the fact that overhead wires will be largely used by any supply company to whom they may grant a concession. If it be considered undesirable to have overhead wires, this is a strong argument in favour of the Vestry undertaking the work themselves. Another advantage gained by the Vestry doing the work themselves is, that the conduits laid for the conductors might be used for introducing a very complete system of fire alarms and signals.

The question, however, which must decide this point is largely one of cost. Will the street lighting cost the parish less when in their own hands, and will the charges for private lighting in this case be also less? There can be only one answer to this question, which is discussed in the third section of this report. The street lighting will cost very little more than at present if undertaken by the Vestry, and the private lighting will be done by them for charges about one-half of those proposed by electric lighting companies. . . .

The reason why the Vestry can so far benefit the residents of the parish are obvious. A supply company has usually to spend more in obtaining sites, carrying out works, breaking up streets, &c., than a Vestry; they must pay, besides the working expenses, a dividend; directors' fees must be paid; the whole capital must be paid back in 42 years, after which time they lose the goodwill in the business they have created. With a Vestry or other local authority this is not so, and the expenses of erecting and managing works are far less. . . . Finally, as will be seen from the second part of this report, a Vestry can economise fuel by burning the dustbin refuse of the parish, which it now costs over £1,000 a year to get rid of. In view of these facts, I have no hesitation in recommending the Vestry to undertake the electric lighting of the parish themselves.

2.—The Best Scheme for Generating and Distributing the Electric Current if the Vestry Undertake the Work.

I do not advise the Vestry to enter upon this work unless they thoroughly realise that this is no experiment, and that they are prepared to undertake to supply all the electric light required in the parish. . . .

The work which has to be done divides itself naturally into two parts :—(1) Street lighting, to be paid for by the rates; and (2) private lighting, to be paid for by the consumers. The parish will be divided into two districts, A and B, of which A is the richer and B the poorer portion. The district A will be dealt with immediately *in toto;* the district B will be added in due course.

I have taken into consideration every practical system of distribution which might be adopted, and I have no hesitation in arriving at the conclusion that the following plan is the most satisfactory which can be adopted for lighting the parish of Paddington, limiting my remarks in the meantime to district A.

Street Lamps.—There will be about 400 arc lamps, carrying a current of 9 or 10 amperes, giving a light which is spoken of in the trade as being 2,000 candle-power. The lamp-posts will be 30ft. high, and separated to a distance of about 80 yards. Additional illumination may be given in special cases, and the position of lamps has been so chosen that there will not be a single dark slum or mews in the whole district. The illumination may be looked upon as fully thirty times as good as the present illumination by gas. The lamps will be connected to eight circuits, 50 lamps being in series on each circuit. The lamps will be supplied with a current continuous in direction. Ultimately half the lamps will be put out at midnight. At present all are to be lighted together. A tracing is shown, which may be placed over the map of the district, showing the proposed arrangement of mains. The object aimed at has been to arrange the eight circuits so as to overlap. Thus, if ever it should chance that one circuit was defective, the streets would not be in darkness. This tracing is liable to modifications when it is actually decided to proceed with the work.

Conductors.—The conductors will consist of copper wire, insulated with vulcanised India-rubber and covered with protecting braid, and will at present be drawn though cast-iron gas-pipes, placed, where possible, under the foot-pavement, and in other cases under the kerb or in the roadway. Some of the long-feeding conductors may be carried along either of the railways if the necessary permission is obtained.

Private Lighting.—The private lighting, whether by incandescent lamps or by arc lamps, will be carried out by means of an alternating current combined with converters. By this means high-pressure currents can be carried through thin and comparatively cheap conductors over the whole district, and converted into the low-pressure currents required for private lighting by means of the induction apparatus called converters. Each of the street lamp-posts will have a space at its base, closed by a door. No joints of any kind will be allowed in the conductors, except inside these receptacles in the lamp-posts. When a house asks for the electric light branch conductors will be led from the nearest lamp-post into the house, where a converter will be placed. The mains laid down in accordance with this scheme will be supplied with current by conductors, called feeders, from the central station, the number of these feeders and their points of attachment being increased as the demand for light increases. The mains over this district will be sub-divided into sections, each supplied from a

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separate feeder. It will be noticed that the private mains are totally independent of the street-lamp mains. Conduits being once laid, the mains for private lighting can be drawn in as required. Owing to this separation of the private and street-lamp mains the services of lamplighters are dispensed with, as the lamps can be lighted up or put out from the central station.

The Central Station.—The best site for the central station is in the neighbourhood of the Vestry's dust wharf, but no difficulty would be experienced if another site were preferred. Provision must be made at the outset for the supply of a maximum current for 10,000 incandescent lamps of 16 candle-power, or the equivalent in lamps of different candle-power, consuming about 1,000 horse-power, besides about 400 horse-power for the arc lamps. The size of the dynamos required will depend upon the practice of the manufacturer whose tender is to be accepted. The engines to be adopted will probably be compound tandem engines, working at high pressure. Condensing will not be adopted in the first instance, because, until the consumption of lights is very large the fuel will be an unimportant item and the cost of procuring condensing water will be excessive. But later on it will probably be desirable to sink artesian wells for this purpose.

Boilers and Furnaces.—A great economy can be effected by using the dustbin refuse of the parish as fuel. In connection with this part of the subject I have inspected numerous places where refuse is so burnt, but I do not find that the plans hitherto adopted are generally suitable for the present purpose. In many of these it is the practice to put on the furnaces everything which it is desired to get rid of, including animal matter in the form of sewage and also diseased meat and carcases of animals generally. This produces bad odours, and in the present case only the dustbin refuse should be burnt. I have examined this refuse in the parish of Paddington, and find it largely composed of coal, cinder, wood, and other materials which burn well. With ordinary care in firing no black smoke is ever seen. In cases where boilers have been used they are generally looked upon merely as an adjunct to the apparatus for destroying refuse, and are not efficient in producing steam from the heat of combustion, 150lb. of fuel being required in many cases to generate the steam for one horse-power for one hour. I have, however, prepared a design for combining a suitable furnace with a boiler in such a manner as to produce an efficient result, where we may certainly expect to obtain in actual practice one horse-power for one hour from the consumption of 15lb. of fuel. [A tracing of the proposed arrangement is appended to the report.]

If this system be adopted there will be a residue, consisting of a clinker or a slag, whose weight is about one-fourth of the total weight of fuel used; and a proper means of disposing of this must be prepared. At Bolton this clinker is pounded and mixed with lime and made into mortar, which is sold at a considerable profit. The Vestry of Paddington might dispose of a large quantity of their clinker in this way. At Southampton the clinker is pounded up and mixed with cement and made into paving slabs, which have a life of at least six years, and which are used by the Corporation for the paving of footways, thereby introducing a great economy. The Paddington Vestry may well adopt this plan on a very large scale. In the same way conduits for the electric light conductors may be made, which will be extremely suitable for the extension of the Vestry's electric lighting works.

Future Additions.—Although I have said that 10,000 incandescent lamps of 16-candle power, or the equivalent current, is enough to start upon, the fact must be realized that the cost of production and the cost charged to consumers will be reduced by an addition to this number. The reason of this is that the conduits sufficient for the larger number must be laid and other expenses incurred in the first instance, so that, to increase the number of 16 candle-power incandescent lamps to 25,000 with the same kind of machinery would not require a proportionate increase of capital. The first increase, however, to the capacity of the central station will be effected by establishing secondary batteries in the bath-houses owned by the Vestry, situated in the centre of a district requiring a large amount of light. These batteries will be charged during the day-time by the same machines which during the night are supplying the arc lamps. This will give a very large increase of output from the machinery with very little additional expense.

Preliminary Work.—If the Vestry resolves to undertake the work themselves immediate action must be taken to prepare the necessary drawings and specifications previous to asking for tenders. A trial of the plan proposed for utilising town refuse must also be made, for which purpose a small boiler and furnace should be put down, which might be utilised in preliminary trials for disposing of the refuse clinker.

3.—The Cost of Laying Down and Working Electric Lighting Plant.

In preparing the following estimates for the guidance of the Vestry I have considered it necessary to separate the street lamps from the private lighting. The estimates of capital expenditure include everything that is necessary for starting the works in a thoroughly satisfactory condition, giving current to 400 arc lamps in the streets and maximum current equal to that required for 10,000 incandescent lamps of 16 candle-power. This amount is found in actual experience to meet the requirements of 15,000 lamps actually put in place, only two-thirds being ever in use simultaneously. The estimates include cost of laying conduits over the whole district, so that with a few days' notice the supply can be given to any customer in the whole district.

The general result arrived at is that the total capital expenditure amounts to £95,540, of which £38,500 is spent on arc lighting in the streets and £55,040 on the private lighting, and £2,000 on mortar mills and paving-slab works. The annual expenditure on arc lights, including contingencies, is £5,096; the depreciation account is £1,898; and the annual payment of interest at 3½ per cent. and capital to be repaid in thirty years is £2,050; total, £9,044. The charges which would be made by a supply company for this lighting with underground conduits would be from £12,000 to £15,000. The annual expenditure on private lights, including contingencies, is £3,320; the depreciation account is £2,600; and the annual payment of interest at 3½ per cent. and capital to be repaid in 30 years is £2,970; total, £9,390.

There is some difficulty in examining the figures with respect to the arc lighting with a view to comparison with the present cost. In the first place, I have been unable to separate out the street lighting account in past years for the district A apart from the whole parish. And again, the plan proposed of disposing of the dustbin refuse introduces a great saving, which ought to go to the credit of the public department represented by the street arc lamps. In the annual report of the Vestry for the year ending March 25, 1888, the expenses of lighting the streets amount to £7,993, less a balance in hand of £749, giving a total cost £7,244; of this probably one-half, say £3,600, is spent upon the district which I call district A. The cost of sifting the dustbin refuse and removing it, less the receipts from sales of materials, is not easy to arrive at. It appears that a sum of £3,871 is spent in wages, sifting, haulage, canal dues, loading and unloading, of which £1,594 is for wages in collecting the dust—the difference is a saving of £2,277; but there are further expenses which it is difficult to apportion, but certainly there will be a saving of £168 for the engineer and assistant and stoker, making a total saving in the dusting department of £2,445, from which must be deducted the present profits from sales of materials, amounting to £1,065, leaving a total saving of £1,380. This, added to the £3,600 now spent in lighting, gives £4,980 as an approximate estimate of present expenses which will be abolished when the streets are lighted by electricity. I believe, however, that if the accounts could be properly sifted it would be found that this estimate is somewhat under the mark.

The private lighting is much more easy to deal with, though even here there is some uncertainty. Most of the district is of a residential character, and if we wish to be on the safe side it is not safe to allow for each lamp an average period of lighting of more than two hours a day, let us say 700 hours per annum. If the customers are charged by meter, with a rental for the meter of 14 shillings per annum, with an average of 50 lamps to the house, and at the rate of 4½d. per Board of Trade unit, the receipts will amount to £9,507. The total expenditure of all kinds, including depreciation and also annual payment of interest and capital, is £9,320, leaving a balance of £187. The cost at which supply companies in the metropolis are proposing to charge customers is from 7½d. to 1s. per Board of Trade unit, with a considerable supplementary annual charge generally added.

By the time that the 15,000 lights provided for as above are all taken up the demand for electric lighting will be pretty well established in the district, and it may be well to point out, that with an additional expenditure of about £40,000, involving total annual charges of about £5,000, in addition to the above estimate, the total number of lamps supplied would be increased from 15,000 to 37,500, increasing the income in the proportion of 5 to 2, which would reduce the charge which would have to be made to less than 4d. per Board of Trade unit.

I have not prepared detailed estimates of the expenses and receipts in connection with disposal of the clinker by converting it into mortar, paving-stones, &c., not having been able, so far, to obtain accurate data as to the prices which will be obtainable. I have, however, no doubt that this part of the business will add considerably to the profits of the undertaking, while the additional expenditure on account of capital is certainly not likely to exceed £2,000.

In preparing the estimate supplied herewith I have assumed that the work of laying the conduits is to be undertaken by the Vestry itself. If let out to contract the cost would be somewhat in excess of the estimate now arrived at.

It has been already stated that the cost of street lighting by electric arc lamps will be but little in excess of the present cost of street lighting. The estimates show a difference of £4,064. I feel confident that this, however, means no addition to the rates, but rather the contrary, because residents will be attracted and the ratable value of the parish sensibly increased by the great improvement proposed in the lighting of the streets.

The following is a statement of capital, expenditure, and cost of working:—

Preliminary Estimates.

Capital Expenditure on Street Arc Lamps.

Proportion of buildings, foundations, smoke-shaft, &c.	£5,000
Boilers, furnaces, brickwork setting, small engine, fan, pumps, steam-pipes, &c.	2,500
Ten dynamos for arcs (two spare), five engines (one spare), 400 arc lamps, belts, switches, instruments, and accessories	14,000
Tools, &c.	250
One-third of 25 miles conduit	5,450
Thirty miles cable, with laying and jointing	3,000
Four hundred lamp-posts and fixing	4,800
Engineering expenses and contingencies	3,500
Total for street lamps	£38,500

Annual Cost of Street Arc Lamps.

Depreciation on boilers, machinery, and lamps	£1,650	
„ cables	150	
„ buildings, &c., and lamp-posts	98	
		£1,898
Proportion of wages and salaries	1,350	
Proportion of rents, taxes, water, oil, waste, and stores	500	
Carbons	2,616	
Contingencies	630	
		5,096
Annual payment, interest and capital		2,050
Total for street lamps		£9,044

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Present Annual Cost of Street Lighting.

Present cost for street lighting	£3,600
Present extra cost in dealing with refuse	1,380
Total cost at present	£4,980

Capital Expenditure on Private Lighting.
(15,000 16 candle-power lamps.)

Proportion of buildings, foundations, smoke-shaft, &c.	£10,000
Boilers, furnaces, engines, dynamos, and accessories, with traveller, spare machinery, and converters (for supplying a maximum current for 10,000 lamps of 16 candle-power)	23,500
Tools, &c.	750
Three hundred meters	2,100
Two-thirds of 25 miles conduit	10,800
Thirty miles cable, with laying and jointing	3,000
Engineering expenses and contingencies	4,890
Total for private lighting	£55,040

Annual Receipts from Private Lighting.

15,000 lamps of 50 watts each, averaging 700 hours per annum, at 4½d. per Board of Trade unit	9,297
Rent of 300 meters	210
Total for private lighting	£9,507

Annual Cost of Private Lighting.

Depreciation on boilers and machinery	£2,350	
,, buildings	100	
,, cables	150	
		£2,600
Proportion of wages and salaries	2,150	
Proportion of rents, taxes, water, oil, waste, and stores	1,100	
Contingencies	570	
		3,820
Annual payment, interest and capital		2,970
Total for private lighting		£8,390

Extra Capital Expenditure.

Extra capital expenditure on mortar mills works for paving slabs, &c.	£2,000

Total Capital Required for Works Proposed.

Street arc lighting	£38,500
Private lighting	55,040
Mortar mills, &c.	2,000
	£95,540
Estimated cost for a plan the same as above, but supplying 37,500 lamps of 16 candle-power instead of 15,000	£135,540

THE VAN DEPOELE SYSTEM OF ELECTRIC RAILWAY.

FIG. 1.—Van Depoele Electric Railway at Montgomery, Ala.

We give above illustrations of two electric railways run on the Van Depoele Overhead System. The capital city street line at Montgomery, Ala. (Fig. 1), is one of the largest in the world, having over twelve miles of track, with heavy grades varying from one to eight per cent. The equipment consists of ten cars with ten horse-power motors, and four cars with fifteen horse-power motors. The Windsor Electric Railway (Fig. 2) is a cheaply constructed line, running along the bank of the Detriot River between Windsor and Walkerville.

The Van Depoele Electric Company uses single or double overhead wires, or a conduit, according to circumstances. In the case of overhead wires the traveller usually runs on the top of the conductor, although, in some instances, a contact wheel pressing upwards against the conductor is employed. The overhead conductors in some cases are run in a rather novel fashion; poles are placed along the curb on opposite sides of the streets, from opposite poles a cross wire is strung, and from this cross wire is hung the copper conductor running the whole length of the track. Judging from American experience there can be little doubt as to the cheapness and practical efficiency of the overhead system, but it is to be feared that the narrowness of our streets, to say nothing of æsthetic reasons, will greatly hinder its use in this country.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *March 30th*, 1889.

It would appear that the storage battery decision which has just been rendered by Judge Coxe in the United States Circuit Court here is practically the first of the kind dealing definitely with storage battery priority in this country, and that it may have an important effect on the future of the industry. The decision results from an action brought by the Electrical Accumulator Company against the Julien Electric Company upon four patents, one to Shaw and Rogers, one to Camille A. Faure, and two to J. W. Swan. The action was for infringement, which the Julien people denied, setting up various pleas of defence. Judge Coxe has taken the trouble to go into the subject in a very thorough and exhaustive manner, and his decision presents an interesting review of the progress of the art. The decision affects directly three patents, the first of the four patents in suit, that to Shaw and Rogers, being withdrawn by

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the plaintiffs from the litigation, and practically given up. As to the two Swan patents, these were declared invalid, one being on the preparation of plates with perforations, cells, or holes extending through the plate into which the active material is packed, and the other on pretty much the same thing, "the support in the form of a plate with angular or equivalent holes or perforations extending through the same and separated from one another by webs, holes, or partitions of uniform cross-section, the active material being placed in said holes, &c." The first patent, No. 312,599, issued February 17th, 1885, was invalidated on the evidence of Prof. Eaton, of Brooklyn, who showed that as far back as 1881 and 1882 he made plates with perforations, his evidence being corroborated by witnesses who assisted in making the batteries and in punching the holes. The second patent the Court threw out because it held that after the first patent there was absolutely no room for the second. "When a patent has been granted for a plate containing rows of holes, another patent cannot be granted for the same plate containing uniform rows of holes. Neither can there be anything patentable in the mere shape of the holes. A patent for a device containing round holes will preclude a subsequent patent for the same device with square or triangular holes. Especially is this so when the applicant is confronted with his own express declaration that the shape is wholly immaterial."

The debatable ground thus being narrowed down to a consideration of the Faure claims, the Court goes into an elaborate discussion as to their merits, and concludes by recognising Mr. Charles F. Brush, of Cleveland, Ohio, as entitled to be considered the first inventor and patentee in this country of secondary batteries in which the active coating is mechanically applied. The Court says that after the patent, No. 252,002, of January 3rd, 1882, was granted to Faure, interferences were demanded by Brush, and on an investigation into his work they resulted in a decision in Brush's favour at all stages during the progress through the Patent Office. As to his priority on the broad method of applying the active material mechanically, Judge Coxe characterises the language of the Faure specifications as loose and inaccurate, and says that construed under it, therefore, the first claim is anticipated in every form except that in which the active material takes the form of a "paint, paste, or cement." Judge Coxe also declares against the broad sense of the Faure claim of the same patent, in which the grouping of the plates in a series of cells with non-porous partitions between them is described. This method of grouping is held as not being a new combination of familiar elements, but as a combination for which there was precedent and which would occur to anyone versed in the art. Having thus ruled on the claims, the Court has intimated that if all the Faure patent in claim I. be disclaimed except the specific method of applying the coat to the plate by means of "paint, paste, or cement," it will sustain the patent on such a claim. When this has been done the Electrical Accumulator Company will be entitled to an injunction and to an accounting, but in the meantime it has been taxed with the costs, and the Julien people now assert that it is not their practice to employ the active material in such a manner as a paint, paste, or cement, but as a dry powder. It is claimed by the representatives of Brush that this decision, with its narrowing of the Faure claims and the cancelling of the Swan patents, puts the Brush patent in the first place as one which must be recognised as a master patent by the Electric Accumulator Company as well as by others. This being the case, the results will be interesting and important in their bearing on the future of the storage battery.

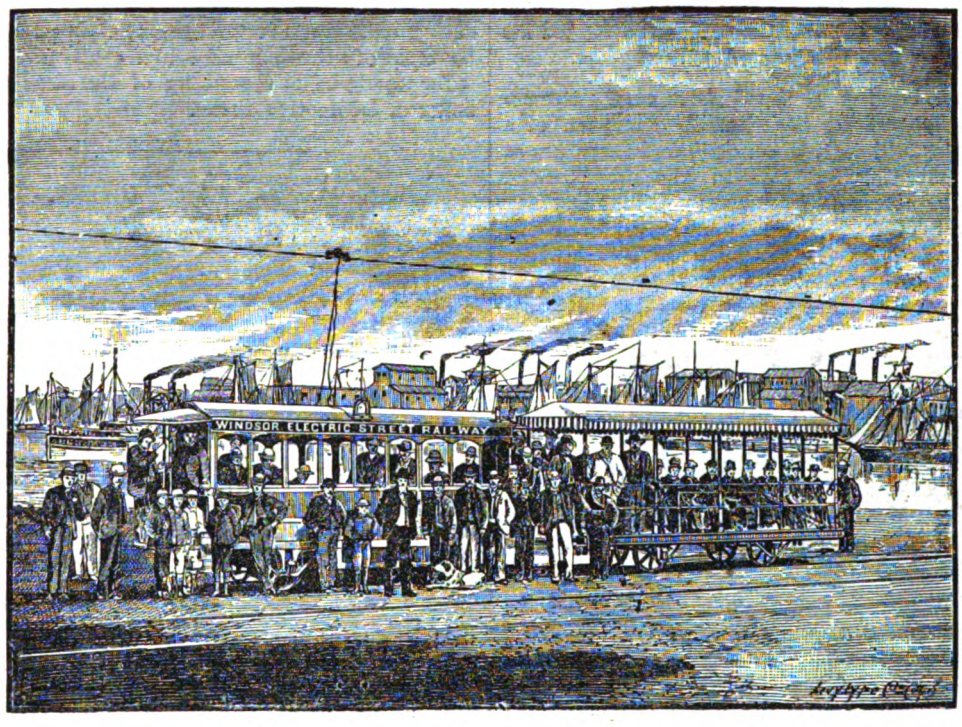

Fig. 2.—Windsor Electric Railway.

Interesting, too, is the fact that the decision thus rendered gives pre-eminence to the work of two American inventors in this field. Other American investigators of the subjects are considered, but their work is not characterised as reaching that degree of practical success which would entitle them to the control of the commercial storage battery. Thus reference is made to Kirchoff's U.S. patent, No. 31,545, in which the coatings of the plates were described as being produced out of and at the expense of the storage battery fluid, and as the gradual and slow result of charging. Reference is also made to the work of Dr. Van der Weyde, who gave evidence as to what he had done fourteen and twenty-five years ago. The doctor well deserves the compliment paid him by the judge, in speaking of him as a man of great learning and research, restless, energetic, and untiring in his labours in the dark and profound

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mine of science. But the Court pointed out that if such a keen and ingenious man were the author of the great improvement made practical by Faure, it was extraordinary that he should have allowed the secret to languish and perish. Moreover, he doubted whether a man so busy, writing 5,000 articles on scientific subjects in a few years, would have had time to carry out work in this field exhaustively, or if he had done so, would not have recorded it in one of the 5,000 articles. Besides, the doctor during those years took out more than 30 patents, yet he did not consider it of sufficient value to make it the subject of a patent. On these grounds the Court held that it was not right to regard Dr. Van der Weyde's work as a satisfactory anticipation. There can be no doubt that the learned doctor has dabbled in every branch of electrical science and work. Those who attend the meetings of the New York Electrical Society in this city say that nothing is ever brought before that body but Dr. Van der Weyde is ready to recall something of his own exactly like it, and sometimes he produces the identical apparatus, dusty and mouldy and worm-eaten, as though he had just exhumed it from the catacombs of Greenwood. In fact, the doctor is a little like the well-known burgomaster in one of Offenbach's comic operas, who could never resist the inclination in his speeches to get back to the "year one," and who was regarded in consequence by some unkind people as very much of a bore. This is the doctor's only failing, which should be forgiven him, for he is undoubtedly a master of electrical science, and deserves much better luck than has attended his ceaseless and unwearying investigations these fifty years.

As I have said, the bearing of the decision on the storage battery art is important, as we have already some ten or a dozen companies in the field in this country, and there are at least half a dozen promising batteries in the experimental shape. The work to be done, too, grows every day, and it may be safely said that in electrical circles generally here the storage battery is in much greater favour than it was a year ago. The Electrical Accumulator Company announce this week that they have recently made some successful experiments in Philadelphia, and that Brill, of Philadelphia, is completing half a dozen more cars for them. The Julien Company, who regard the decision in an exceedingly jaunty and chipper way, report themselves as very busy, and John Stephenson, the car builder, has just received an order from them for 30 cars to be run on the Julien storage battery system on the Fourth and Madison-avenue line in this city. From Detroit encouraging reports come of the work done there in traction by the Woodward storage battery. Altogether this field promises to be full of activity during the present year.

There is a good deal of talk nowadays about electric light consolidations and combinations, and the *New York World* of Tuesday last has a column and a-half article on the growth of the business, and on a "trust" which it alleges to be near at hand. I would not attempt to deny the statements contained in the article, but if leading companies, in spite of their open and avowed attacks upon each other in the courts, as well as their vigorous statements in the columns of the papers, are actually engaged all the time in making amicable arrangements for a trust or combination, then I can only say that they are remarkably adept at concealing their emotions or assuming sentiments which do not inspire them. According to the *World*, a prominent electrician said to the reporter: "It is an open secret in electrical circles that a trust or a consolidation is practically agreed upon, and it will probably materialise in tangible form as soon as a few more of the pending suits are adjudicated. Each company wants to hold as many trumps as possible before showing its hand. A combination is, however, recognised as a foregone conclusion, but I have not learned whether it is to be a trust, a combination, or an absorption. The Brush Company is the only one making money, and it is in a position to dictate terms; but I understand there is money enough at the back of the Westinghouse Company to buy up all competitors on a reasonable valuation based on their profits and prospects. There has been a tendency towards consolidating electric light and power interests for some time, and there are now really only three or four important parent companies. Consolidation would not only do away with disastrous business rivalry, but would greatly lessen the expense of the service by abolishing and consolidating plants. Electricity is the greatest scientific and commercial factor of the age, and five years hence it will have more than doubled its capital and business if properly encouraged, but the heavy stockholders realise that concessions are necessary if profits are desired. The cut-throat practices have hindered the business, and not only prevented profits but hampered the growth of electric light and power. Although it has not been pushed as other enterprises have it has grown miraculously—has overcome monster obstacles by reason of its own inherent worth—and with a fair chance it is impossible to conceive what it would accomplish." The article closes by stating gravely that there are excellent reasons for believing that the rumours about the trust are well founded, and that the conclusion will be reached during the present year. It will be noted in the quotation I give that the Brush Company is spoken of as the only one making money. You will remember, however, that in my letter last week I gave some figures showing the Thomson-Houston Company to be doing very well. It is also stated that the Edison business is in good shape, and from the way the Westinghouse Company has been absorbing smaller concerns it is to be inferred that they have plenty of money and are quite satisfied with their prospects. The Western Electric Company is also believed to be doing remarkably well, and there are a number of other companies, all of which appear to be very active. Now that the business is down to a manufacturing basis there seems to some observers to be as little reason for trying to throw it all into a combination or trust as there is for trying to do something of the same kind with engine or boiler or locomotive works.

PARIS NOTES.

(FROM OUR CORRESPONDENT.)

April 9th, 1889.

The whole range of the Boulevards, from the Place de la République to the Madeleine, are in the hands of workmen, and at every corner the people passing meet holes of about one metre in diameter and four to six metres deep, joined together by trenches running alongside the footpaths about eighty centimetres wide and one metre deep. These excavations are intended to receive the mains of the companies which have undertaken to light the Boulevards. On account of the great traffic at these points, the companies have not been allowed to open the streets, and at the crossings they have been obliged to tunnel under the branch sewers which join the main sewers on the Boulevards. The general lighting will consist of about 190 arc lights of 10 amperes, worked and installed by the Edison Company, the Marcel-Deprez Company, and the Victor Popp Company. The motive power will be steam for the two first, and compressed air engines in the case of the Popp Company. The lamps will be placed on posts six metres high, erected in the middle of the street, sixty metres apart. Similar work is being carried out at the Place du Carrousel by the Edison Company, and by the Company du Secteur de la Place Clichy in the neighbourhood of the Rue St. Lazare, adjoining the Gare St. Lazare and the Terminus Hotel, where this company will light the shops under the hotel, the street, and the entrances to the station with 15 ampere arc lights manufactured by the Société Alsacienne at Belfort. Numerous private plants are being pushed on in different parts of the city, and the serious efforts which are being made everywhere foreshadow a large display of electric light.

On Wednesday night last, after the meeting of the Société Internationale des Electriciens, the present members of the committee visited the Station du Palais Royal. An explanation of the system was given by M. Fernies. The whole plant reflects great credit on the Edison Company and their chief engineer. Contrary to the Parisian Gas Company, which seems still to believe that the electric light is only a nice toy, the provincial gas companies of Angers, Montauban, and Rouen have been authorised by their shareholder to lay down electrical plants and to offer to their consumers either electricity or gas. The Compagnie du Gaz de Lyon, for whom a station was erected last year by the Société Alsacienne, is more and more satisfied at having taken this step, and sees without regret the daily increase of the demand for electric light.

The provisional installation of 45 1,000 candle-power arcs, which has been put up by the Edison Company on the Champs de Mars, is now completed, and night work will therefore now be possible. The motive plant is divided into two groups, each comprising a Weyber and Richemond portable engine and a dynamo giving

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223 amperes and 75 volts. I may mention in this connection that M. Bechmann proposes to augment the brilliancy of the illuminated fountains at the Exhibition by the device of projecting the jet through an annular orifice, the beam of light being directed through the centre of the opening. By this means a hollow jet is obtained, and the loss of light due to transmission through the water in the chamber is avoided. It is, however, perhaps a question whether the perpendicular part of the jet will not appear less brilliant than before, since it would seem that less light will find its way through the water until the jet begins to break.

A few days ago the Conseil Municipal suddenly remembered that it had to nominate the "commission technique," consisting of three members, which is to deal with matters relating to the station at the Halles Centrales. Several names were proposed, but no agreement was possible, and after deciding to increase the number of members to five the councillors adjourned. Meanwhile the progress of affairs is arrested. The question of the lighting of the left bank of the Seine has again come before the Conseil Municipal. Four concessions have been asked for, but there seems little likelihood of their being granted, the financial question proving insuperable. It seems probable that the present "concessionaires" will be asked to extend their areas across the Seine, and that the main streets on the far side of the river will be included in the scheme of experimental lighting which the Conseil propose to carry out during the Exhibition period. An electric railway will be commenced shortly between the Porte d'Orleans and Montrouge.

The first scheme which the Government brought forward with regard to the French telephones has been dropped, and a new project is now before the Chamber. The Government requests permission to buy up the Société Générale des Telephones "in toto," purchasing all its instruments, wires, and exchanges. The State will borrow the sum necessary to effect this, the loan to be paid back in ten annual instalments, 40 per cent. of the gross receipts being set aside for this purpose, the remaining 60 per cent. being devoted to the expenses of working and maintenance. The tariff will be considerably reduced, and it is anticipated that the consequent development of the system will enable the loan to be paid off in less than 10 years if so desired. After arranging the question of finance and the case of towns already provided with exchanges, the Bill proceeds to deal with the case of towns as yet unprovided with a telephone system.

At a recent meeting of the Conseil Général de la Seine it was decided to invite tenders for lighting the Asylum at Vaucluse by electricity, and the sum of 142,000fr. was voted. The Asile de Vaucluse is 35 kilometres from Paris, and if the light proves a success there electricity will be gradually introduced into all the establishments controlled by the Conseil Général.

A large central station is in progress at Amiens. Some 5,000 lights have already been applied for, and it is reported that the magnificent cathedral of this town will shortly have the electric light.

CORRESPONDENCE.

DEFLECTION OF AN ELECTRO-MAGNETIC WAVE BY MOTION OF THE MEDIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: This subject is of interest in connection with theories of Aberration, which requires to be explained electro-magnetically. A plane wave in a non-conducting dielectric is carried on at speed $v=(\mu c)^{-\frac{1}{2}}$, where μ is the inductivity and c the permittivity, and is not altered in any way, according to the rudimentary theory, that is to say, which overlooks dispersion. But if the medium be moving through the ether, it is altered in a manner depending upon the speed of motion and the angle it makes with the undisturbed direction of propagation.

Thus, let $\mathrm{E}_0=\mu v\mathrm{H}_0$ specify a plane wave in a medium at rest, E_0 being the tensor of the electric and H_0 of the magnetic force. Next set the medium in motion with velocity $\mathbf{u}$, changing $\mathbf{E}_0$ to $\mathbf{E}$ and $\mathbf{H}_0$ to $\mathbf{H}$, thus

$$\mathbf{E}=\mathbf{e}+\mathbf{E}_0, \qquad \mathbf{H}=\mathbf{h}+\mathbf{H}_0 \quad . \quad . \quad . \quad . \quad (A)$$

where $\mathbf{e}$ and $\mathbf{h}$ are the auxiliary electric and magnetic forces due to the motion. To find them, we have, first, the electric force due to motion of matter in a magnetic field, or

$$\mathbf{e}=\mu\mathrm{V}\mathbf{u}\mathbf{H} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (B)$$

which formula is well known, and is included in Maxwell's treatise. Next, the magnetic force due to motion in an electric field, or

$$\mathbf{h}=c\mathrm{V}\mathbf{E}\mathbf{u} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (C)$$

This equation, which is as necessary as (B), was, so far as I am at present aware, first given by me in one of the early sections of my "Electro-magnetic Induction and its Propagation," January or February, 1885, and was again considered later on in connection with the "magneto-electric force," which is as necessary as Maxwell's "electro-magnetic force."

We require one more relation, viz., between $\mathbf{E}_0$ and $\mathbf{H}_0$, viz.,

$$\mathbf{H}_0=c\mathrm{V}\mathbf{v}\mathbf{E}_0, \quad . \quad . \quad . \quad . \quad . \quad . \quad (D)$$

the property of a plane wave, due to Maxwell; and we can now fully find the auxiliaries $\mathbf{e}$ and $\mathbf{h}$ in terms of the originals $\mathbf{E}_0$ and $\mathbf{H}_0$. Here $\mathbf{v}$ is the vectorized v of the wave when undisturbed.

In the above V is the symbol of vector product. Thus $\mathrm{V}\mathbf{u}\mathbf{H}$ is the vector perpendicular to $\mathbf{u}$ and to $\mathbf{H}$, whose tensor equals the product of *their* tensors, u and H, into the sine of the angle between their directions. But this is merely used to state the general relations in a compact and intelligible form, instead of with Cartesian abominations.

Instead of taking the general case, it is convenient to divide into three, viz., (1) $\mathbf{u}$ parallel to $\mathbf{v}$; (2) $\mathbf{u}$ parallel to $\mathbf{E}_0$; (3) $\mathbf{u}$ parallel to $\mathbf{H}_0$. By putting the results together we shall obtain the mixed-up general case.

(1) $\mathbf{u}$ parallel to $\mathbf{v}$. Here the medium is moving in the same direction as that of undisturbed propagation, and there is no alteration of direction of either $\mathbf{E}_0$ or $\mathbf{H}_0$, so that it is only necessary to specify the tensors of the auxiliaries $\mathbf{e}$ and $\mathbf{h}$. Thus:—

$$e=-\frac{u}{u+v}\mathrm{E}_0, \qquad h=-\frac{u}{u+v}\mathrm{H}_0 \quad . \quad . \quad (1)$$

If, for example, the medium be moving at half the speed v, and *with* it, the displacement and induction in a given length are spread over a space half as great again as if the medium were at rest, so that their intensities are reduced to two-thirds of the undisturbed values. There is no discontinuity when u is equal to or greater than v.

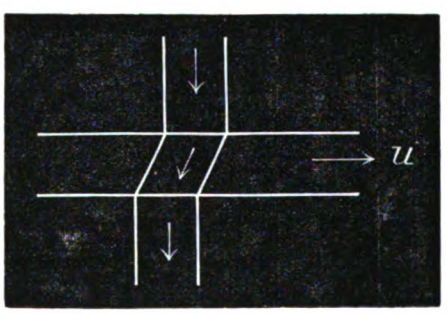

FIG. 1.

But if the medium move the other way there is compression into half the space, so that the intensities are doubled. As it is increased up to v, the compression increases infinitely. After that, with $u>v$, there is reversal of sign of $\mathbf{E}$ and $\mathbf{H}$ as compared with $\mathbf{E}_0$ and $\mathbf{H}_0$.

(2) $\mathbf{u}$ and $\mathbf{E}_0$ parallel. Here $\mathbf{h}_0$ is parallel to $\mathbf{H}_0$, but $\mathbf{e}_0$ is parallel to $\mathbf{v}$. Their tensors are given by

$$e=\frac{uv}{v^2-u^2}\mathrm{E}_0, \qquad h=\frac{u^2}{v^2-u^2}\mathrm{E}_0. \quad . \quad (2)$$

(3) Lastly, $\mathbf{u}$ and $\mathbf{H}_0$ parallel. Now $\mathbf{e}$ is parallel to $\mathbf{E}_0$, whilst $\mathbf{h}$ is parallel to $\mathbf{v}$. Their tensors are

$$e=\frac{u^2}{v^2-u^2}\mathrm{E}_0, \qquad h=\frac{uv}{v^2-u^2}\mathrm{H}_0. \quad . \quad . \quad (3)$$

In either case, (2) or (3), the angle of deflection θ is given by

$$\tan\theta=\frac{uv}{v^2-u^2}; \quad . \quad . \quad . \quad . \quad . \quad (4)$$

consequently the deflection is wholly independent of the plane of polarisation.

Thus, let a slab of (say) glass move in its own plane at speed u, and a plane-wave from the upper medium strike the glass flush. The transmitted rays are deflected as shown in Fig. 1, the deflection being given by the above formula, where,

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observe, v is the speed in the *glass* when at rest, and u the speed *of* the glass with respect to the external medium.

The above working out of the effect of moving matter on a plane electro-magnetic wave is (if done properly) strictly in accordance with electro-magnetic principles. But it will be observed that Fresnel's result, relating to the alteration in the speed of light produced by moving a transparent medium through which it is passing, is not accounted for. It is said to have been thoroughly confirmed by Michelson. I should like to direct the attention of electro-magneticians to this question, with a view to the discovery of a modification of the above data, or correction of the working, in order to explain Fresnel and Michelson, which *must* be done electro-magnetically. Mr. Glazebrook has made Sir W. Thomson's extraordinary contractile ether do it by an auxiliary hypothesis; surely, then, Maxwell's ether equations could be appropriately modified.—Yours, &c.,

OLIVER HEAVISIDE.

THE WIRING OF HOUSES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read Mr. Andrews' Paper on "Wiring Buildings for Electric Light" with very great interest, and am very much inclined to follow his lead. Whilst reading the Paper the thought struck me—why not earth one wire as suggested, connecting to gas and water pipes, and *leave it bare?* You would then save the expense of covering it, and might put the money so saved into extra good quality of insulation for the other (say the negative).

For indoor work, wire very lightly covered with lead might be used, and using the lead sheathing as positive lead, of course connecting a bare copper main to it at frequent intervals, to get the requisite conductivity. This would have the advantage of being waterproof, which I don't see is possessed by Mr. Andrews' armoured cable—I mean that the water is able to get at the insulation—is cheap, and also fulfils Mr. Andrews' object, viz., to convert a "partial short circuit" or "opening circuit" into a "dead short circuit." What do your readers think of this plan?—Yours, &c.,

GEORGE T. PARDOE.

LEGAL INTELLIGENCE.

United Telephone Company v. Siemens Bros. and Co.

In the Chancery Division of the High Court of Justice on Monday last, before Mr. Justice North, the action of the United Telephone Company Limited) v. Siemens Bros. and Co. was disposed of, the parties having come to terms. The action was brought for an injunction to restrain the defendants from infringing the Bell Telephone Patent.

It appeared that the defendants had supplied instruments manufactured by Messrs. Siemens and Halske, of Berlin, to certain persons in this country, and among others to Messrs. Lucas and Aird, on account of the War Department, for use on the proposed Suakin-Berber Railway. This railway was not proceeded with, and the instruments were brought back to this country and were recently put up for sale by the War Department.

The United Telephone Company immediately gave notice that they should take proceedings against any person purchasing and using the instruments, and they subsequently took action against Messrs. Siemens Bros. (Limited) for having imported the instruments from Germany and sold them in this country. The defendants admitted the infringement, but pleaded that they had acted inadvertently, and under these circumstances an injunction was taken by consent, the defendants paying the costs of the action and nominal damages, and the offending instruments (which had been recovered by the defendants from the War Department) being surrendered to the plaintiffs.

Mr. ASTON, Q.C. (with him Mr. Micklem), for the plaintiff, said that minutes of an order had been arranged, which Mr. Higgins, Q.C., for the defendants, had seen. The only point he desired to mention was this. There was an order that the defendants deliver up 16 telephones, which he understood were in the possession of the War Office, and upon these being given up the plaintiff company would be prepared to supply any telephones which the War Office might require.

His LORDSHIP said he did not see what he had to do with this, as the War Office were not parties to the action.

Mr. ASTON said that was so, but the telephones were in their possession.

Mr. HIGGINS said the order was made by consent. The parties were *sui juris*.

His LORDSHIP: I have not looked at the terms. I suppose they are all settled.

Mr. HIGGINS: Yes, my lord.

Durtnall v. Shippey Brothers.

At the Canterbury County Court on Tuesday, before His Honour Judge Selfe, the plaint of Durtnall *v.* Shippey Brothers, electrical engineers, of London, was a claim for wages amounting to £13. 16s. alleged to be due from the defendants as the promoters of the Herne Bay Electric Light Company.

In the course of the case the Judge stated there was no such thing as the Herne Bay Electric Light Company. It had never been formed or registered.

Mr. SHIPPEY said there was a syndicate against whom his firm were going to proceed for their money. He was a member of that syndicate, and would have to pay his share.

In giving judgment, His Honour said there appeared to have been two agreements entered into, one for a joint tenancy of certain premises, between Mr. Hamilton and Mr. Shippey, and the other between the same parties with reference to the work of carrying on the business. He was of opinion that Mr. Shippey and Mr. William Hamilton were partners in the business, and that whatever arrangement was made in March, 1888, on behalf of the Universal Electric Light Company to discontinue their arrangement with Mr. Hamilton, who had engaged the defendant, that arrangement had no effect in putting an end to the partnership.

Judgment was then given in favour of the plaintiff for £9. Defendant applied that judgment might not be entered up at present, with a view to his endeavouring to settle up the Herne Bay business, but the Judge declined to do this on the ground that he did not think a postponement would be of any service.

Cardiff Electric Engineering Company.

At Cardiff County Court on Wednesday, before his Honour Judge Owen, Messrs. Kotyra and Ivicki, described as managers of the Electric Engineering Company, Exchange, Pier-head, Cardiff, were called to answer a judgment summons for £13, which had been taken out against them by Mr. Louis Barnett. Mr. Braham Barnett appeared for the plaintiff.

Mr. KOTYRA only answered to the summons, and stated that he was unable to pay the instalments for which an order had been made, as he only received £1 a week. He did not know anybody connected with the Company except Mr. Watts.

The JUDGE (to the defendant): Mr. Watts is the company, and you and the other defendant are managers at £1 a week. Who pays the rent?

DEFENDANT: Mr. Watts. He pays £10 to £15 a year.

His HONOUR thought defendants could pay the instalments, and made an order committing them to 14 days' imprisonment in default.

THE CARDIFF ELECTRIC ENGINEERING COMANY.—The following, letter, which appeared in a recent issue of the *South Wales Daily News* will be read with some interest:—"Sir: I read in your issue of the 4th inst. a report headed 'Another Mysterious Cardiff Company,' &c. Kindly permit me to explain that there is no mystery connected with the Electric Engineering Company. The firm of Messrs. Kotyra and Ivicki having been twice sold up by the sheriff's officers, I, at the second sale, bought the whole of the plant, and removed it from Castle-street to the Merchants' Exchange, Pier Head Docks, where the business is now carried on as the Electric Engineering Company. Surely there is nothing 'mysterious' about this, as it is well known that thousands of people trade as a company although there may be only one in it. Being myself a plumber, of course I do not pretend to be a judge in electric work, therefore it suits the company's purpose to employ Messrs. Kotyra and Ivicki, whose reputation as skilled artisans is well known, and has for years been established not only in Cardiff but in South Wales and the West of England.—Yours, &c., F. T. WATTS."

COMPANIES' MEETINGS & REPORTS.

The Eastern Extension, Australasia and China Telegraph Company (Limited).

The thirty-first ordinary general meeting of this Company was held on the 10th inst., at Winchester House, Old Broad-street, under the presidency of Sir John Pender, K.C.M.G.

The SECRETARY (Mr. F. E. Hesse) read the notice calling the meeting and the minutes of the last meeting, which were confirmed by the present meeting and signed by the Chairman as correct.

The CHAIRMAN said: Ladies and gentlemen, before asking you to approve the resolution which I shall submit to you for the adoption of the report, I will, as usual, make a few remarks upon the results of the last year's working. I am sorry that I cannot congratulate you on the brightness of the day, but I hope that the statement I shall place before you will to some extent compensate for the extremely unfavourable weather. The gross receipts for the half-year have amounted to £238,854, against £232,660 for the corresponding period of 1887, showing an increase of £6,194. This amount would have been considerably greater had it not been for the loss of subsidy (£2,744) and traffic, probably an additional £5,000, resulting from the unfortunate interruptions of the Australian section referred to at the last meeting, in addition to which there has been during the half-year the heavy loss of £6,947 on exchange, in consequence of the increased depreciation of the silver currency. The latter, of course, could have been averted by collecting larger payments from the telegraphing public, but as this would be practically increasing the tariffs, the Company do not wish to resort to such a step if it can be avoided. The working expenses for the half-year have been £71,519, against £69,570

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for the corresponding period of 1887, showing an increase of £1,949, which is mainly due to the cost of repairs to cables being heavier during the past half-year than in 1887. Comparing the figures for the whole year, however, the results are as follows:—Gross receipts in 1888, £478,780, against £451,861 in 1887, showing an increase of £26,919, or over one per cent. on the share capital, whilst the working expenses for the same period show a decrease of £4,900, as follows:—1888, £140,911; 1887, £145,811. One interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to pay another of like amount on 15th inst., making, with the interim dividends for the first half-year, a total dividend of 5 per cent. for the year. It is also proposed to distribute a bonus of 3s. per share, which will make a total payment of 6½ per cent. for 1888. The balance of £66,101 has been carried to the general reserve fund, which now stands at £690,454, as shown by the following figures:—Amount of fund at end of 1887, £620,095; interest added during year, £23,244; balance of revenue, £66,101; total, £709,440; less cost of further partial renewals of the Java-Australian cables off the Lombok Straits, £18,986, leaving a balance of £690,454. In addition to which £15,401 has been charged against revenue for the cost of completion of the renewals of the Singapore-Saigon cable, and £4,492 for rebuilding staff quarters at Cape St. James. The net result, therefore, of the past year's working is that the reserve fund has been increased by £70,359; the cost of renewals of the Singapore-Saigon and Java-Australian cables, together with the rebuilding of the staff quarters at Cape St. James, amounting altogether to £38,879, have been paid for out of revenue; and 6½ per cent. distributed amongst the shareholders. It will be seen from the printed report that further drawings of the Company's Five per Cent. Debentures have taken place since the close of the half-year, which, when paid off, will reduce the capitals outstanding as follows:—Five per Cent. 1880 issue (the issue having been originally £100,000), £12,500; and of the Australian Government subsidy issue a balance will remain of £417,000, the amount having originally been £640,000. No provision has, however, yet been made for meeting the £320,000 Six per Cent. Debentures falling due in 1891. I hope I shall be able to put before you shortly a scheme for dealing with these debentures. Since the close of the year, the laying of the new cable between Java and Western Australia, to which reference was fully made at the last meeting, has been successfully completed. This extension, which gives the Colonies a third cable to Java, and brings into use the Western Australian land lines as an alternative system to the South Australian overland line, was not needed to meet traffic requirements, the existing cables between Java and Port Darwin having a large margin of carrying capacity, but to strengthen the system and minimise as far as possible the risk of interruptions in the future. The cost of the new cable, about £130,000, will be dealt with in the current year's accounts, and will probably be debited to the reserve fund. As stated in the report, a satisfactory arrangement has been concluded with the Colony of Tasmania for renewing the exclusive privilege of telegraphic communication between Tasmania and Australia, which by effluxion of time would expire next year, and for continuing the subsidy of £4,200 a year for the same period. For some years previously differences of opinion had existed between the Company and the Government as to the interpretation of the contract in regard to the payment of the subsidy after the termination of the twenty years' exclusive concession, the Company contending that by the terms of the contract the subsidy was payable in perpetuity so long as the communication was efficiently maintained, whereas the Government argued that the Colony could not be bound in perpetuity, and that the obligation must cease with the concession. Negotiations were, however, eventually entered into with a view to averting the unpleasantness and uncertainty of legal proceedings, and the following compromise was arrived at, which will secure the Company's position in Tasmania for the next twenty years, namely: The exclusive concession is extended for a further term of twenty years, the subsidy is continued for the same period, a traffic guarantee of £5,600 is given by the Government, and the Company is exempted from all taxation and duties chargeable in the Colony. This arrangement has been ratified by the Tasmanian Legislature and embodied in a formal agreement exchanged with the Government, so that all differences with the Colony are now satisfactorily adjusted. With regard to future operations, I may mention that it is proposed to renew during the current year the shallow water portion of the Saigon-Hong Kong cable, where we have had a great many repairs lately. About 300 nautical miles of cable will be required, costing at least £20,000. The amount expended on renewals and duplications up to date has been £444,239, making, with the £690,454 added to reserve, a total of £1,134,693 taken from revenue since the commencement of the Company's operations. Our repairs, however, are a very serious item, costing annually between £50,000 and £60,000, the cost from the beginning having averaged about £40,000 per annum. Now, gentlemen, I have given you, I think, a very full and accurate statement of our affairs. I have taken you entirely into our confidence, and have shown you what we have done during the last few years. Probably nothing that we have done has given more satisfaction than the prompt way in which we laid the third cable to Australia the other day. When we found that the two cables were interrupted and that the important commercial traffic was consequently severely suffering, we thought that if we were to maintain our position we were bound to give additional security. We therefore did not hesitate to enter into a contract without delay for a third cable, and it is now laid as a reserve. Everything is going on satisfactorily. I might say that we have only one cable interrupted at the present moment, but our duplicate and triplicate cables make the working so safe that that is scarcely worth referring to. As I have said on previous occasions, we know where a break occurs, and it does not alarm us much. The repair, of course, takes time, and there is the cost involved also; but as to being able to effect the repair we have never any doubt. I repeat now, with more confidence than I have said on any previous occasion, that we have now a substantial property to deal with. I may mention—and it is very remarkable, too—that whenever our general meetings come round we have some shareholder who takes a greater interest than others in your Directors' policy. Generally the reference is as to the dividend we ought to pay. A great many suppose that in the midst of our prosperity we ought to go on increasing the dividend every year. The communication we have received this time comes from a lady, who asks why we should not pay 2 per cent. bonus this year instead of 1½ per cent. I think I have shown you in the course of my remarks that we have taken this year out of revenue an amount which far exceeds this ½ per cent. bonus which the lady refers to. We did pay at one time an additional ½ per cent., but in view of these renewals and repairs and the fact that we may next year have to take part in another International Telegraph Conference, when the question of our tariffs may again be discussed, I think you will see the importance of our having a strong reserve fund. We made considerable sacrifices in our rates at the Berlin Conference, and we may find it necessary to reconsider our tariffs at Paris. We have to a great extent recouped the reductions we made at Berlin, and I have no doubt that if we decide to make further concessions at Paris the growth of our business will eventually recoup us for the reduction. I hope, however, that you will give us credit for exercising prudence and protecting your interests. If you do not get the additional bonus in money you get it in the increased price of your shares, and it is difficult for you to have it both ways. I think that a large reserve fund makes us independent, and enables us to meet such an emergency as we had to face the other day, when we laid the Western Australian cable. The more we can strengthen our reserve fund, and make our dividend from quarter to quarter steady, and one that can be depended upon, the more I believe we shall increase the value of your property, and the more we shall be doing justice to the interests of the community we represent. I think I have told you everything that it is necessary for you to know—in fact, everything that we know ourselves—affecting the general interests of the Company; and I say with all confidence that no company can be in a more satisfactory and progressive condition than the Eastern Extension Company at the present moment. I now beg to move:—

"*That the report and accounts of the Directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share together with a bonus of 3s. per share, both free of income-tax, payable on the 15th inst., making, with the previous distribution, a total payment of 6½ per cent. for the year 1888.*"

The Right Hon. Viscount MONCK seconded the motion.

Mr. JOHN NEWTON congratulated the Directors on the substantial position attained by the Company. So long as their dividend ranged between 6 and 7 per cent. he should be satisfied, and he had no doubt that that feeling would be shared by the majority of the proprietors. With reference to the remark of the Chairman as to submitting a scheme hereafter for dealing with the Six per Cent. Debentures, he hoped that no mortgages would be raised on the property of the Company, and he suggested that there should be a further issue instead of ordinary shares at par to the shareholders, as in every way more advantageous to the Company.

The CHAIRMAN, in reply, observed that he had only, as it were, thrown out a hint in reference to the question of dealing with the debentures, for the reason that 6 per cent. seemed such a large rate of interest for a company in their position to pay. They would do nothing in any scheme that might be proposed that would in any way injure those who had invested money in the Company. The matter was, however, in embryo at present, but perhaps at the next meeting they would have something to lay before the shareholders which would enable Mr. Newton to speak with figures before him.

The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by Lord TWEEDDALE Sir James Anderson was re-elected to his seat at the Board, as was also Mr. F. A. Bevan, on the motion of the CHAIRMAN, seconded by Mr. G. G. NICOL.

The auditors, Mr. Henry Dever and Messrs. Welton, Jones and Co.' were then re-elected.

On the motion of Mr. GIBB, a cordial vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN: There is nothing that gratifies the Directors more than the approval of the shareholders. We are doing our very best to maintain this great system of submarine telegraphy in the position that it ought to occupy—namely, approved by the Imperial and Colonial Governments and by those who use it, and, I may also say, giving fairly satisfactory results to those who have invested in it.

The meeting then separated.

Electrical Power Storage Company (Limited).

The eighth ordinary general meeting of this Company was held on the 10th inst., at Winchester House, Old Broad-street, under the presidency of Sir Daniel Cooper, Bart., G.C.M.G.

The SECRETARY (Mr. Holland Dell) having read the notice convening the meeting,

The CHAIRMAN said: I now propose to offer some remarks and explanations upon the report and the figures in the statement of accounts where they seem to call for observation. During the past year there has been a gratifying increase of business. This increase is mainly made up of a great number of small orders for storage batteries, which are employed for the variety of purposes detailed at length in the Directors' report. By far the larger portion of the gross profit of £13,273. 15s. 3d. has been earned in the manufacturing branch of the business, as the firms and companies on the Continent who have agreed to manufacture E. P. S. batteries under royalty have taken a longer time to complete their arrangements than was anticipated. There is an increase of £165. 5s. 9d. in the item of rates

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and taxes, owing to the payment of income-tax. We have not done so much advertising lately, so there is a diminution of £293. 6s. 8d. in that account. The shares allotted last year to the Managing Director have been charged against the reserve at par value. The Company has taken out what we believe to be valuable patents in the United Kingdom and in several Continental countries for improvements in details of arrangement in the E. P. S. accumulator, and also for distributing apparatus in connection therewith, and much time and thought has been given by Mr. Frank King, our chief engineer, and our technical staff to perfecting what is commonly known as the E. P. S. system of distribution by storage batteries. On the other hand, law costs and patent fees account is less by £194 2s. 3d., because we have had no professional fees to pay and are for the present free from litigation. The amount allowed for doubtful debts has proved more than ample for the purpose, and there is a balance over which we consider sufficient for this year. There has been, as mentioned in the report, some additional outlay owing to the increase of business on the plant and buildings at Millwall works, and further outlay will have to be made this year. The amount under the heading of sundry creditors is larger, but against this is the increase in sundry debtors account, while the cash balance at the bankers is £3,000 more than it was last year. In the report is given a selection from a long list of new electric light installations in which E. P. S. batteries are used. Reference is also made to various scientific and technical institutions which have adopted accumulators, and I do not think I need here enumerate them. You will have noticed that E P. S. storage batteries are now used for all kinds of purposes—train lighting, ship and yacht lighting, omnibus and carriage lighting, and for power in tramcars, electric launches, and again for surgical purposes. In short, their use is becoming general, as you will have gathered from the paragraphs which have appeared in many newspapers during the past year, and you may take it that, though the name of the E. P. S. Company has not always appeared, yet in 99 cases out of 100 the batteries were the E. P. S. type. Among the latest interesting applications of batteries I would mention the printing at the office of the *East Anglian Times*, at Ipswich, by power supplied by E. P. S. batteries, which are placed at the central lighting station of Messrs. Laurence, Paris and Scott (Limited), in that town, a description of which was sent to the shareholders with the report. I must now dwell for a moment on the subject of central station lighting, the importance of which to this Company cannot be overstated. The Company has applied for Provisional Orders for Paddington, St. Martin's, and the Strand Districts, and an Inquiry is now being carried on under the instructions of the Board of Trade, upon questions which relate to the whole of the applications for Provisional Orders in the metropolis. I shall refrain from making any observations thereon, as the matter is still *sub judice*. I will now pass to the Chelsea Electricity Supply Company, which is supplying light in the Parish of Chelsea. You may not be aware that this is the first company which has supplied electric light in London under the statutory powers of a Provisional Order. It has acquired these powers by Act of Parliament Vic. 50, cap. 18. The E. P. S. Company, in conjunction with the Anglo-American Brush Company and the Callender Bitumen and Telegraph Company, took up the Chelsea Company last July, and contracted to furnish the necessary plant, and they have now carried it through to its present stage; and I feel confident that the combined efforts of the three companies, each in its own special line, will result in a model central station. The system of distribution is that of the E. P. S. Company, by which the current is supplied from the main station to storage batteries placed in convenient sub-stations throughout the district to be supplied. We believe this system to be the best for such populous districts as Chelsea, and that the public will give the preference (when once they become acquainted with its essential features) to the only system in which a reservoir light, in case of accident from any cause whatever, is provided. Our Managing Director, Mr. Courtenay, is a Director of the Chelsea Company, having joined the Board at our request. You will, perhaps, have read the pamphlet issued by the Electrical Accumulator Company of New York. I need only remark that judgment has now been given against the Julien Company for infringing the Faure patent, and therefore that company will be put under injunction. The trial of this suit has taken more than twelve months, and the investigation has been one of a most searching and exhaustive character. The shrewd advisers of the American Company consider, as they state in the document referred to, that they had already got the control of the accumulator business in the States from their other patents, even without the Faure patent, and now that they have this basic patent also declared valid their position should be doubly assured. I beg to move the adoption of the report and accounts, and ask Mr. Sellon to second the resolution.

The VICE-CHAIRMAN (Mr. J. S. Sellon): Gentlemen, in seconding the resolution I have very little to add upon general points to the remarks of the Chairman, or to the matters dealt with in the report. It would, of course, have been gratifying, and doubtless for many reasons acceptable to all of us—and certainly more pleasant to the Directors—if we could have arrived at the conclusion to recommend the division of a dividend. One large shareholder remarked to me after the report had been published that if we had declared a dividend our shares would have immediately doubled in market value. This may be the case, although, in view of what is before us, I see no reason why our shares should not quadruple in value without our troubling ourselves about the dividend at present. In my view, the Directors are bound to consider the exigencies of the business they direct, and are not justified in diverging from what they consider necessary for the protection of the internal interests of the undertaking simply in order to affect the external value of the shares. It has been a labour of years to build up this business, to overcome violent antagonism, and to establish the secondary battery upon a firm basis as an indispensable and reliable factor in electric lighting. This has been at last accomplished, and a first great start given. Would it not be unjustifiable to do anything that might cripple us for a moment in grappling with the great extension of work before us! Instead of diminishing the resources at our command, we could with considerable profit employ further capital; in fact, every £1,000 in a growing business of this kind is of value, and I may say that, realising this, your Directors have not, I think, for at least fully two years taken out any of their well-earned fees. On former occasions I have somewhat exhaustively dealt with most of the technical questions in connection with this undertaking, and I have pointed out the wide and expansive range of work which lies before us. I need not therefore now detain you with any further remarks on such points, but perhaps you would permit me to say a few words on your position as owners of patents. [The Chairman alluded to the recent important decision given in the Courts of the United States in favour of the Faure patent after one of the hardest patent fights on record.] With the exception of one decision—sustaining one of the Thomson-Houston patents for an arc-light regulating device—this is the only electrical apparatus patent pertaining to lighting or motor business the litigation on which in the Courts of the United States has terminated favourably for the patentee. The Faure patent is one of those which, as you know, is held by the Electrical Accumulator Company of America—a powerful corporation formed to work our patent rights in the United States, and in which, I am glad to say, we hold a very considerable interest. The importance of the decision will be obvious to you when I explain that this patent entirely controls the use of active material applied to the plates, and I assure you that no efficient and practical secondary battery can by any known means be made without such application. It is a fundamental and essential point of construction. I ought perhaps to mention at the same time that the Swan patents for the simple perforation of the plates, came before the same Court and was not upheld; but the decision did not arise from any invalidity in the invention itself, but upon a matter of form, proof not having been put forward, probably through an oversight, as to the earlier date of the English patent compared with that taken out in the United States. If considered necessary, this can doubtless be put right, and its priority, which is incontestably capable of proof, can be established. But in any case the matter is of no great importance. Though the patent is an important one in itself, the manufacture of the plates, as carried on by all the infringers, comes within the claims not only of the Faure patent, which is upheld, but of several others in the group of the E. P. S. patents held by the Electrical Accumulator Company. Neither here nor anywhere else where we have patents is this Swan patent affected by any decision of the United States Court. I would take this opportunity of explaining to you that you possess in the E. P. S. group of patents some forty of more or less importance, fully covering each and every point and detail essential to our business; and, so far as is within my knowledge, not one single outside patent exists which would be of use to us in the manufacture, or, as they say in America, would be worth "a red cent" to us. Several of the patents are, as in the case of the Faure, governing or controlling patents in the sense that no economical and efficient secondary battery can be constructed without infringing them. Every perfect plate now made embodies the principle of no less than four of these patents in its manufacture, and in the completed cell others of minor importance as to details come into play. As several of these patents are of recent date compared with our basic patent, you have the great advantage of the prolongation of the term of your practical monopoly of manufacturing storage batteries, because, naturally, the most perfect battery is the one which will always command the market. You will therefore feel justified in considering your position in this important and indispensable branch of the electrical industry to be not only unique but unassailable. I would only further remark that, as time passes and experience is gained, the more absolute is the confirmation of the views put forward by myself and a few others some eight years ago, but doubted and criticised at the time by many electricians, even of eminence, that it is to the employment of the secondary battery that we must look for the attainment of the most reliable, safe, economical, and generally acceptable system of electric lighting; and I confidently anticipate that one of the results of the important investigation now being carried on under Commission of the Board of Trade sitting at Westminster Town Hall—which is literally absorbing the interest of the electrical world of England—will be to enable not only electricians, but the general public, more vividly to realise the solid and permanent advantages of the storage system which this Company advocates and controls. I have the pleasure to second the resolution for the adoption of the report and accounts.

Mr. SCHOMBERG said he had hoped on the receipt of the report to see the prospect of some return for the money he had had in the undertaking now for some years, especially when he saw that the net profit for the year had been £8,372. A dividend of 2½ per cent. on the capital of £150,000 would still have left a balance of £4,622 in the hands of the Directors, which he thought a very large sum to keep in hand to conduct a business like theirs. The Directors stated in the report that it had been a matter for their anxious consideration how to raise additional capital. Instead of the shares being as they were now, 10s., they would have been 15s. had a dividend of 6d. a share been recommended, while they would have been at par had a distribution of 1s. a share been proposed. That would have enabled the Directors to issue the balance of the capital of the Company at par. He congratulated the Directors on their attaining to the position of having no litigation. He would like to know the rate of interest paid on the debentures, and how it was proposed to raise the additional capital.

Mr. J. W. BARCLAY, M.P., said he could not agree with the views expressed by the last speaker. It would be a great misfortune if they were to starve the Company more than it was already. The capital of the Company was still inadequate for the further development of the business that was now opening to the Company, and he thought it would be a great misfortune if the shareholders were further to impoverish the capital by paying a dividend. He believed the course advocated by the Directors, who were large shareholders, was wise and judicious in the ultimate interests o' the Company. His principal object, however, in rising was to congratula the Directors and his brother shareholders on the very greatly mprov.

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position which the Company had now attained, and he thought that the best thanks of the shareholders were due to the Chairman and Directors for the pluck and energy with which they had striven, and with so much success, to bring the Company from what was well nigh a desperate position into one which gave promise of very satisfactory, he might almost say brilliant, results for the future. He had an idea that the position of the Company was in reality much better than appeared on the face of the accounts. He believed that the inquiry which was going on at Westminster would bring before the public in some intelligible form the merits and demerits of the various systems of electric lighting now in vogue, and he had very great confidence that it would be proved conclusively that the E. P. S. system was not only as economical, if not more economical, than any other, but, in point of fact, the only system which could be relied upon to give satisfaction in electric lighting to the public. If, as he believed, that should be proved, there would be at once an enormous development of the business of the Company, because, if it proved as he had indicated, the whole system of electric lighting, not only in this country, but in Europe, would be dependent upon the supply of the article which their Company manufactured and which it alone possessed. If they turned to the report—and it had been confirmed by the Chairman—they would find that a large portion of the profits had been obtained from the manufacture of the article. and that on a very limited scale ; but he looked to very large profits—perhaps the largest portion of the profits—coming from royalties in other countries, and it was satisfactory to know that arrangements had now been completed in Germany, France, and Austria for the immediate development of the storage battery. That could not fail in the course of the present year, and more so in succeeding years, to bring in a large revenue to the Company. The Chairman had said comparatively little about the American company, in which their Company held such a large interest.

Mr. SCHOMBERG: What is our interest in that company ?

The MANAGING DIRECTOR (Mr. J. I. Courtenay): I will reply to that presently.

Mr. BARCLAY, continuing, said he had reason to know that the American company was in the hands of very able, energetic, and influential men, and he would not be surprised if within the next few years the value of this Company's interest in the American company would be equal to the whole of their capital. If the shareholders would only exercise a little more patience, they would, he had no doubt, reap a brilliant result at no distant period.

A SHAREHOLDER: Did not the first speaker over-state the amount of the profit for last year ?

The MANAGING DIRECTOR: The shareholder is quite right in drawing attention to the fact that the balance at the credit of the profit and loss account is the amount stated of £8,372, but that was not all made in the past year. The debentures bear 7 per cent. interest. With respect to the question of providing further capital, the Directors are not prepared at the moment to lay before you a scheme. I hope in the current year, however, that the Directors will propose a scheme taking into account the debentures that fall due in May next year. It will be necessary in our scheme for obtaining further capital to deal with the debentures, and we also propose to deal with the question of providing further capital.

A SHAREHOLDER: You will not deal with the matter without consulting the shareholders ?

The CHAIRMAN: As to the balance unissued, I dare say, when the shares go to a premium, we may consider the issue of a portion of them. We have to keep shares to the amount of £25,000 in reserve against the debentures. If the shares went to a premium at an early date the position would be very much simplified.

A SHAREHOLDER: The shareholders would have the preference ?

The MANAGING DIRECTOR: My impression is that the shareholders have the preference. The total debentures authorised amount to £25,000, but the Directors themselves have been advancing money to the Company.

The CHAIRMAN: The Directors make themselves personally liable to the bank whenever they want certain money.

The MANAGING DIRECTOR: The debentures are not all issued, but the Directors have advanced money against them, and, as they charge only 1 per cent. above the Bank rate instead of 7 per cent. which the debentures carry, they effect a saving to the Company of between 2 and 3 per cent. In regard to the question of our interest in the American company, I own that we have always been extremely reticent, but the Directors have now desired me to mention it. The total amount of our interest is nominally at par value £120,000, but I urge the shareholders not to form any exaggerated estimates from that statement. I believe that they have control of the business all over America. We are now in the midst of a hot conflict of systems in the metropolis, but I do not believe that the Storage Company will come out the worst.

The CHAIRMAN put the motion, which was unanimously adopted.

The retiring Directors, Sir D. Cooper and Mr. Courtenay, were afterwards re-elected.

The CHAIRMAN returned thanks for his re-election. He assured them that it had been no easy task to manage the Company. He and his colleagues had remained on the Board solely in the interest of the shareholders, and with the determination to do their utmost for them. He would not go into details, but if they had not repeatedly made themselves liable for considerable sums of money the Company would not now have been in existence.

The retiring Auditors (Messrs. Deloitte, Dever and Co.) having been re-elected,

Mr. BARCLAY proposed and Mr. SCHOMBERG seconded a vote of thanks to the Chairman and Directors, and the resolution was carried unanimously.

The CHAIRMAN, in reply, assured the shareholders that the Directors would continue to do all they could to promote the success and welfare of the Company.

Montevidean and Brazilian Telegraph Company (Limited).

The ordinary general meeting of this Company took place on the 9th inst. at the offices, Tokenhouse-buildings, Moorgate-street, under the presidency of Dr. Charles Cameron, M.P.

The SECRETARY (Mr. James Fraser) read the advertisement convening the meeting, and the report of the directors was taken as read. It stated that the percentage of gross revenue receivable from the Western and Brazilian Telegraph Company showed a considerable increase, being £3,604, as compared with £2,508 in 1887, and the directors were glad to note that, so far as could be judged from the published returns of the Western and Brazilian Company, the traffic continued to improve. An amount of £142 was charged against revenue under the heading "New Debentures." This represented the cost of obtaining subscriptions for £8,500 new debentures, bearing interest at the rate of 6½ per cent. per annum, to replace old debentures of that amount which bore interest at 8 per cent. per annum. They recommended the payment of a dividend at the rate of 3s. 6d. per share on the Preference shares (being 1¾ per cent. per annum), which would absorb £1,455, leaving a balance of £54 to be carried forward.

The CHAIRMAN moved the adoption of the report and accounts for the year ended December 31 last. He stated that the present report was more favourable than those which had been submitted on any previous occasion—a fact owing to the improvement in the revenue of the Western and Brazilian Company, on whose earnings their own revenue depended. The auditor's certificate was as follows:—"London, 30th March, 1889. Examined with the books and vouchers of the Company and found to be in accordance therewith. The Western and Brazilian Telegraph Company having objected to an inspection of their books, I have not been able to verify that percentage of earnings payable to the Montevidean Company." This difficulty had arisen under an agreement by which the Platino Company had a right of inspecting the Western Company's books, to which for many years their own auditor had access. After a while, however, the Western Company objected.

A SHAREHOLDER inquired if the point had been legally tried.

The CHAIRMAN replied in the negative, adding that they had not been in a position to spend money on legal proceedings. Continuing, he said he was glad to state that the Western Company had withdrawn their refusal of an inspection of their books, and their accounts had been inspected by the auditor of the Montevidean Company since the issue of the report now under consideration. In future they would meet with no difficulty in that respect. They had been enabled to replace their old debentures, which were issued at a time when the Company was in embarrassed circumstances, and when they were glad to raise money at even 8 per cent ; and they had issued a like amount at 6½ per cent. They had not gained any advantage this year by the alteration, the difference in the old and the new rate of interest having been swallowed up in the commission they had been obliged to pay to the gentleman who had carried out the operation. The old debentures used to be redeemed at the rate of £500 a year, but the Directors considered that that was dangerously slow progress, and the new issue they had arranged, with the shareholders' approval, to pay off at £1,000 per annum.

Lieut.-Colonel G. W. MACAULEY seconded the resolution, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. JOICEY, M.P., the dividend recommended was next agreed to.

Mr. JOICEY then proposed, and Mr. CANTON seconded, the re-election of Lieut.-Colonel Macauley as a director, and the motion was unanimously agreed to.

After the reappointment of the auditor (Mr. W. S. Ogle),

A vote of thanks to the Chairman was passed on the motion of Mr. CANTON, seconded by Mr. PFEIL, and the proceedings then terminated.

The Telephone Company of Ireland.

On Saturday, the 6th inst., the proprietors of this company held their tenth ordinary general meeting at the offices of the Company, Commercial-buildings, Dublin. Alderman Winstanley presided.

Mr. W. F. BOTTOMLEY (Secretary) read the notice convening the meeting.

The report, which appeared in our issue of the 29th March, was taken as read.

The CHAIRMAN, in moving the adoption of the report and statement of accounts, said that a dividend at the rate of 1½ per cent. on the ordinary share capital of the Company for the year ending 31st December last had been declared, and that the *ad interim* paid in August last at the rate of 1 per cent. per annum for the half-year ending the 31st June be confirmed. He said the total number of subscribers, it would be observed, was 970 on the 31st December, 1888. Owing to a change, however, in the mode of keeping the records so as to accord with royalty accounts an exact comparison could not be made, but it might be stated that the increase in the number of the Company's subscribers still continues. The Post Office having opened a telephonic exchange in Cork some years ago, the Directors were for some time unwilling to establish a competing telephone exchange in that city, until it could be seen whether the facilities given by the Post Office fairly met the requirements of the public ; but when, after the Post Office exchange had been opened for more than three years, it was found that the number of subscribers was limited to 30 to a population of about 100,000, whilst the number of exchange subscribers to the Company's telephone exchange in Dublin, with a population of less than 300,000, was upwards of 700, it became obvious that the telephonic wants of the public in Cork were not being duly provided for. The Post Office department and the Directors having obtained permission from the municipality to erect the neces-

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sary poles in the public thoroughfares, resolved to extend the Company's operations to Cork and the surrounding district. The result had, so far, amply justified the policy of the Board, because on the 1st January, when the Company's exchange was opened, a larger number had already signed contracts with the Company than the Post Office had obtained after three years' work, and the number has already increased to more than 100, which might be considered exceedingly satisfactory for the first three months of the Company's operations there. For the purpose of developing Cork, and opening at Limerick and elsewhere, a call of 2s. 6d. per share was made on the Preference shares. He was distinctly of opinion that the telephone business of the country could be more satisfactorily conducted by private enterprise than under Government control. Personally he was always of that opinion, and he would commend a study of the above figures to those who are always clamouring for Government interference. It is the fashion to commend the administration of the Postal Telegraph Department, but he unhesitatingly asserted that, although the rates charged for telegraph service were very considerably less than in days gone by, still in the days of the old Electric and International Telegraph Company the service between all the more important commercial centres was much more prompt and satisfactory than it is now, and he ventured to say that if the telegraph service in the country were in the hands of private enterprise instead of being under Government control the service would be as cheap and certainly much more satisfactory than it is now. The Company's license from the Postmaster-General was for 31 years from January, 1882, and could not be revoked except by purchase on terms to be settled only by arbitration. He for one trusted, however, that the Postmaster-General would not avail himself of the right which he possessed under the terms of their agreement to purchase out the telephone companies next year, but he did hope that a liberal policy will prevail, and that the companies would be relieved of the heavy royalty of 10 per cent. on their gross revenue which they had at present to pay over to the department, and which was, he considered, an unfair tax upon the most active and progressive section of the commercial community. It was well understood, no doubt, by all the shareholders that the formation of the various subsidiary telephone companies—this amongst the number—effected some years since, was due to the desire of the United Telephone Company to obtain the advantage of the local knowledge and influence of men connected with the various cities and districts in the kingdom to enable the business to be pushed forward rapidly and simultaneously, and but for the obstacles thrown in their way by the dog-in-the-manger policy of the Postal Telegraph Department in the earlier years of the Company's existence much greater progress—satisfactory in one sense as that progress has been—would now be visible. And in this connection he might say that it was greatly due to the exertions of their late lamented Chairman, Mr. E. Dwyer Gray, that the old license from the Post Office was amended in some of its more objectionable features, and a new license granted on somewhat more liberal terms by the late Mr. Fawcett, then Postmaster-General, who grasped the subject in a statesmanlike manner. The business in the various centres having now been firmly established, he thought he ought to tell them that an amalgamation of some, if not all, of the companies, was under consideration, with a view to connecting by trunk wires all the principal centres, thus giving the means of almost instantaneous communication between the more important cities and towns. It might be interesting to some of the shareholders who did not closely follow the development of the telephone to learn that at the present moment there are no less than fourteen wires in constant use for telephonic conversations between Liverpool and Manchester, and the cry was still for more. Only for the misfortune that before this Company was formed the Ulster district had been given over by the United Company to one of the subsidiary companies in England, Belfast would now be connected with Dublin. The Board had actually entered into contracts for the materials of the line in its own district to the County Louth, but the English company preferred rather to develop their large district in England than spend their money here. In the event, however, of the suggested amalgamation of interests taking place, it was possible that the telephone system for all Ireland might be placed under the management here. If that be so, and if the counsel of this Board was followed, the very first step would be to reduce the rates in Belfast to those of Dublin, and to couple up Belfast with Dublin and other towns *en route*. The shareholders will naturally wish to know something about the terms of amalgamation, if such were to come to pass, but all he could say as to that at present was, that the Directors would do their best, consistent with fairness, to obtain such terms as would be satisfactory to the shareholders. He was pleased to say that they were enabled to give the shareholders a small increase in the dividend again upon this occasion. Of course they were aware that the working capital of this Company had been wholly provided by issue of Preference shares, and that each original subscriber to the Preference shares was allotted share for share—one Ordinary share as fully paid up, so as to allow the Preference holders to participate with the United Telephone Company in surplus profits after payment of the dividend upon the Preference shares. Each original subscriber, therefore, who now holds his shares receives £6. 12s. 6d. upon the amount originally subscribed by him, which, under all the circumstances, might be considered, he thought, as satisfactory. It gave him very much pleasure indeed to see amongst them their old friend Mr. Morgan, of London. His presence showed that the working of their Company had given the utmost satisfaction to the parent company.

Mr. ROBERT WORTHINGTON, J.P., seconded the motion, which was adopted.

The CHAIRMAN then moved the re-election of Mr. Arthur Dudgeon and Mr. Robert Worthington, the retiring directors.

Mr. JOSEPH BOND MORGAN, Managing Director of the United Telephone Company, seconded the motion, which was also adopted.

Alderman DILLON moved the re-election of Mr. John M. Kean as auditor, the joint remuneration of the auditor appointed by this Company and the United Telephone Company to be fixed at 50 guineas per annum.

Mr. JAMES EVANS seconded the motion, which was adopted.

Mr. JOSEPH B. MORGAN preposed a vote of thanks to the Chairman, who, he said, had always taken a great deal of interest in the development of telephone enterprise. He (Mr. Morgan) trusted they would always be able to work together in the same harmony and accord. So long as he was connected with the United Telephone Company he would do his utmost to maintain their cordial relations. When the telephone enterprise was just set on foot the Government of the day claimed that it was an infringement on their rights. They had a monopoly of the telegraph system, and the matter went into court, and it was held to be an infringement, but the judge expressed a hope that the Government and the Postmaster-General did not desire to hamper the development of so novel an enterprise. The then Attorney-General, Sir H. James, said the Government had no wish to do that, and that they only desired to have the telephone under their control and to give a license. The license was given after a short time, but as it was only for a limited area, it was found that it hampered the development of the system. Mr. Fawcett, with his broadness of character and pure commercial mind, had the matter brought before him, with the result that they got the license they were now working under. Under the license the system had developed very much, and would have developed more had more facilities been given by the Government with regard to the opening of post offices, &c.

Alderman DILLON seconded the motion, which was adopted.

Alderman WINSTANLEY, in returning thanks, mentioned that last year their gross rentals were £10,193, while this year, taking the first quarter into consideration, they were at the rate of £11,428, showing in the quarter alone an increase of £1,235 over the corresponding period of last year. This was most satisfactory, but of course it included what they had received from the Cork exchange.

The proceedings then terminated.

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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The Electrical Automatic Delivery Box Company (Limited).

An extraordinary general meeting of this Company was held at Winchester House, 50, Old Broad-street, on Wednesday, April 10, 1889, for the purpose of considering and (if thought fit) passing two resolutions respecting the amalgamation of the Company.

Major R. H. Murdoch presided.

The SECRETARY read the notice calling the meeting.

The CHAIRMAN said that they had been advised that day by their solicitor that it would be best if they dealt only with the resolution relating to amalgamation on this occasion, which he proposed to modify as follows :—

"*Resolved, that it is expedient to effect an amalgamation of this Company with the Automatic Trading Company (Limited), and that with a view thereof the Directors be authorised to take the necessary steps to effect the same.*"

The Directors, he might say, would not have advocated this amalgamation unless they had felt confident that it would be to the benefit of both Companies. The amalgamation ought to lead, he thought, to beneficial results for both sides. He concluded by formally moving the resolution.

Mr. DEAKIN seconded.

Mr. ABRAHAMS (the Solicitor) explained the legal aspect of the case, and stated that both this Company and the Automatic Trading Company would go into liquidation, and that a new company would be formed, and the shareholders of both companies would go into the new company on equal terms.

Mr. PAINTER, a holder of 3,000 shares, was in favour of the proposed amalgamation.

In reply to other remarks upon the subject,

The CHAIRMAN of the Automatic Trading Company stated that the books of that company had been open fully to the inspection of the Board of this Company.

The motion was, after a further discussion, in which the adjournment of the meeting was advocated, put and carried.

The CHAIRMAN then stated that if they failed to carry out the amalgamation the Directors would consider the question of selling the Company if they could get fair and reasonable terms. They had had an offer. He wished at that meeting to tender his thanks to several shareholders who had written to him confidentially making suggestions, for which he was obliged, and which he would utilise. He could assure them that their confidence would not be betrayed.

A vote of thanks to the Chairman for presiding terminated the proceedings.

Reuter's Telegram Company (Limited).

Report to be presented at the twenty-fifth ordinary general meeting of the shareholders, to be held at the Company's offices, 24, Old Jewry, London, on Wednesday, the 17th inst., at noon :—

The Directors report that the net profits for the year ending 31st December last, after payment of current expenses, and deducting rebate on unexpired subscriptions, amount to £1,222. 8s. 6d., including £61. 7s. 11d. brought forward from the last account. In accordance with the Articles of Association the Directors have tranferred £3,448. 15s. 2d. from the reserve fund, of which £538. 4s. 1d. is applied to extinguish bad debts, and the balance of £2,910. 11s. 1d. is carried to profit and loss account. From the amount thereby made available for distribution the Directors declare a dividend of 5 per cent., free of income-tax, for the year 1888. This will absorb £3,686. 18s., and leave a balance of £446. 1s. 7d. to be carried forward.

The Directors have to announce with great regret the retirement of their esteemed colleague Colonel James Holland owing to advanced age. The Hon. Mark F. Napier has been elected to the vacant seat at the Board. In conformity with the Articles of Association, Admiral the Right Hon. Sir John D. Hay, Bart., K.C.B., retires from the direction, but offers himself for re-election. Messrs. Welton, Jones and Co. (late Messrs. Quilter, Welton and Co.) offer themselves for election as auditors.

The dividend warrants are payable on the 27th inst.

NEW COMPANIES REGISTERED.

THE NORTHAMPTON ELECTRIC LIGHT AND POWER COMPANY (LIMITED).—Registered by Deacon and Co., 4, St. Mary-axe, E.C., with a capital of £20,000, in shares of £1 each. The object is to carry on a general electric motor and lighting business. Amongst the first subscribers is Mr. R. E. Crompton. The number of directors shall not be less than three nor more than seven. The remuneration of directors shall be determined in general meeting.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 29th, 1889, amounted to £5,351.

EASTERN TELEGRAPH COMPANY.—This company announces the payment by warrant, on May 1st, of interest for the half-year ended 30th April, on their Four per Cent. Mortgage Debenture stock.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company notify that the coupon on their Five per Cent. Debentures (1880 issue), due May 1, will be payable on and after that date at the Consolidated Bank, Threadneedle-street, E.C.—The traffic receipts of this company for the month of March were £42,896, as against £39,670 for the same period last year.

INDO-EUROPEAN TELEGRAPH COMPANY.—The board of directors of this company, at their meeting on April 8th, after adding £10,000 to the reserve fund, determined, subject to audit, to recommend the payment of a dividend for the six months ended the 31st December, 1888, of 17s. 6d. per share, making with the interim dividend already paid 6 per cent. for the year, and a bonus of £1 per share, both free of income-tax, making in all 10 per cent. for the year. The dividend and bonus will be payable on and after the 1st May next.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended March 29th, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Company, were £3,993.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The directors of this company recommend that, subject to final audit, a dividend of 12s. per share be declared on account of arrears of dividend on the first preference shares, placing £1,000 to reserve, and carrying forward £1,154.

CHANGE OF ADDRESS.—The offices of Elmore's Patent Copper Depositing Company (Limited), have been removed to 20, Bucklersbury, E.C.

PERSONAL.—The Woodside Electric Company notify that Mr. Rankin Kennedy has ceased to manage their works. The proprietorship, however, remains the same as formerly, and the business will be carried on under the name of the Woodside Electric Company.

———We are informed that Mr. Neville Moody and Mr. Walter Andreae have established themselves as electrical engineers at 2, Princes-mansions, Victoria-street, under the title of Moody and Andreae. Mr. Moody has been for the last five years with the Anglo-American Brush Electric Light Corporation, and Mr. Andreae was for over two years in the factory of the Anglo-American Brush Corporation, and was subsequently in the employ of Messrs. Schuckert, of Nuremberg. Messrs. Moody and Andreae intend to devote their attention to the supply and erection of plant and apparatus for electric light installations.

———The Acme Electric Works Ferdinand-street, Chalk Farm-road, London, N.W., have been appointed agents for London and a radius of fifty-four miles for the sale of dynamos manufactured by Messrs. F. H. Ryce and Co., of Hulme, Manchester.

———The *Bulletin Financier International* of Rome states that Messrs. Ceresa Formenti and Co., of Lodi, near Milan, have established important works for the manufacture of electric apparatus generally, and in particular for the manufacture of accumulators on a new system invented by Professor Jean Gaudini.

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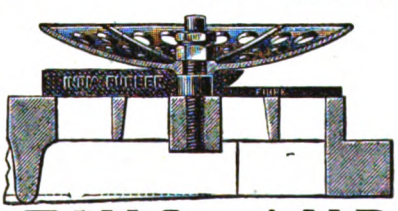
No Rubber, Percha, or Leather.



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Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Price, Wednesday, April 10, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending April 10, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£ 1,770,360	Stock	15/0	Anglo-American	53 54	3 14 1	Jan., Apr., July, Oct.	52⅜	50⅜
2,614,820	Stock	30/0	Do. Preferred	89½ 90½	4 8 5	,, ,,	90	84⅜
2,614,820	Stock	...	Do. Deferred	18⅜ 19⅛	...	February	19⅛	17
130,000	£10	5%	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13⅝	13 1/16
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	101¼	...
75,000	£100	3/0	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 14⅝	6 2 0	February and August	14⅝	14½
6,000	10	10/0	Do. Preference 10%	18⅞ 19½	5 2 7	,, ,,	...	...
12,931	5	1/7½	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	10⅜ 10⅝	4 9 5	Jan., Apr., July, Oct.	10⅛	10
380,000	10	2/6	Eastern	13⅛ 13½	4 7 3	,, ,,	13⅜	13
170,000	10	3/0	Do. 6 per Cent. Preference	15 15½	3 17 5	,, ,,	15⅝	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	106 108	3 14 1	May and November.	108⅛	107
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	4 10 11	February & August	108⅜	...
250,000	10	2/6	Eastern Extension	13⅜ 13⅞	4 13 8	Jan., Apr., July, Oct.	13¾	13⅛
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	103 106	4 14 4	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust	7½ 7⅝	4 13 8	Jan., Apr., July, Oct.	7½	7 1/16
178,992	10	3/0	Do. 6 per Cent. Preference	14⅛ 14⅜	4 1 4	,, ,,	14 3/16	14⅛
150,000	10	5/0	Great Northern	14⅜ 15⅛	4 18 4	Jan., July, and April	15⅛	15 3/16
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	7¼ 7⅜	5 3 2	April and October	7½	...
15,609	10	3/0	West African Telegraph	7½ 8½	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	...	...
30,000	10	6/0	West Coast of America	9¾ 10¼	4 17 7	January and July	9¾	...
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅞ 2	...	...	1⅞	1⅜
34,563	10	12/0*	Do. 1st Preference 6%	10¾ 11¼	...	April and October	11⅛	10⅝
4,669	10	†	Do. 6 per Cent. 2nd Preference	11½ 12½	...	...	12⅜	11⅜
45,181	15	6/0	Western Brazilian	12½ 13	5 15 3	March & September	13	12½
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	1 1/16 1⅛	...	Yearly	⅝	...
220,000	£1	8%	Oriental (11s. paid)	⅜ ½	3 6 1	...	...	...
80,000	5	5/0	United	16¼ 16¾	4 9 7	June and December	16 11/16	15⅞
55,000	5	...	United River Plate	5¾ 6	...	January and July	6	5⅝
			ELECTRIC LIGHT.					
23,003	5	...	Anglo-American Brush (£4 paid)	3¼ 3⅜	...	...	...	...
23,692	5	nil.	Do. (fully paid)	4⅛ 4⅜	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2½ 3	...	...	2 7/8	2⅜
312,000	¼	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42¼	41½
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works xd	17½ 18½	5 8 1	February & August	...	...

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S

DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

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NOTES.

Messrs. Ganz and Co. write to us to the effect that after four years of continuous experiment their electricians, MM. Zipernowski, Déri and Blathy, have succeeded in constructing an alternate current motor, "of absolute practical perfection," which "is in no way inferior to the very best continuous-current motor." Unfortunately the present communication is of a preliminary character, and although it contains an interesting survey of alternate current motors in general, not one word is said about the design or construction of the new motor. Notwithstanding this delinquency we must still attach great importance to any statement put forward in so responsible a quarter and concerning the labours of such accomplished electricians as MM. Zipernowski, Déri and Blathy. We hope shortly to receive full technical details. Meanwhile, the information now to hand amounts to this:—(1) The motor is self-starting, and even the smaller sizes can be placed directly upon a high-tension circuit without danger. Messrs. Ganz point out that in this respect it has a distinct advantage over the continuous-current motor, which at high tension is difficult to handle, and, in fact, cannot be so used below a certain size. (2) Regulation is easily obtained; commercial efficiency over 90 per cent for moderate sizes. (3) The lag introduced is small, so that if the motor is working on a constant potential circuit the maximum value of the current does not become excessive for a given power, as it would if the lag were great. (4) Only one circuit is required. Messrs. Ganz express their conviction that the introduction of this motor completely solves the problem of the distribution of motive power from central stations.

Some weeks ago (*Electrician*, March 1, 1889, p. 474) we stated that a French firm (MM. Worms and Balé) had succeeded after long endeavours in applying electricity to the art of tanning in such away as to immensely accelerate the process. We are now able to give some further information as to the method adopted, and although our knowledge of the art does not enable us to offer any opinion as to the precise value of the invention, yet we are very hopeful that it will ultimately afford an important outlet for electrical apparatus. What is actually done is very simple. The raw hides are placed in large cylinders which revolve upon horizontal axles. Provision is made for passing a current through the drum, the electrolyte being a decoction of tannin. (Further electrical details are at present wanting.) The drum is kept slowly revolving until the process is complete. The time required varies with the nature of the hide. Light calf-skins, sheep and goat-skins, which used to require from four to six months, are said to be completely tanned in 24 hours. Horse and ox-hides require from 72 to 96 hours, whilst by the old-fashioned bark process they would have taken 12 months, or even more. As to the quality of the leather, several French leather merchants have stated that it is above the average in strength, and has all the solidity and suppleness of the best samples. Specimens of harness, &c., made from this leather will be shown at the Paris Exhibition. Furthermore, in addition to the economic value of the immense saving of time, it is stated that the working cost per lb. of dry leather will be only 1¾d. to 2d., as against 3½d. to 4d. per lb., which is the figure now reckoned by the Bermondsey tanners. The number of hands required is said to be only about one-fifth, and the capital expenditure is largely reduced. It is evident that if only half this be true, there is, to say the least, "something in it."

As to the scientific aspect of the question the exact nature of the *rôle* played by the electric current is not at all clear. Prof. S. P. Thompson, who has examined the process, suggests that the effect may be in some way to open the pores of the hides and so permit a more rapid access of the tanning solution, and also that its chemical activity may be increased by the electrolytic action. Mr. A. Zwierzchowski, who is representing MM. Worms and Balé in this country, thinks that the current renders the gelatine more soluble, so that it is able to combine more rapidly with the tannin.

A search in the records of the Patent Office would undoubtedly disclose the fact that this is by no means the first attempt that has been made to tan "by electricity." M. E. Leonardi, in a recent number of the *Revue Internationale de L'Electricité*, mentions several schemes of this nature—all of them failures, the earlier ones necessarily so, from the lack of an economical means of producing current, whilst others suffered equally from a lack of electrical knowledge on the part of the "inventors." It will probably be new to most of our readers to learn that the late unfortunate M. Lucien Gaulard took up this question as long ago as 1877, and after working at it with great industry and determination he obtained results which in 1882 enabled him (according to our informant) to sell the patent rights to an English firm for £1,000, and a royalty on the output. Gaulard's process does not seem to have differed very

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much from that above described, except that he did not rotate the containing vessel. He also began, for some reason, with a a weak solution of tannin, and gradually increased its strength. The process occupied about 12 days.

We publish this week a Paper by Dr. Doubrava, in which he describes a "method of distribution of continuous electric currents by means of condensers." The Paper possesses some interest for the sake of the theoretical discussion, but at present we gravely doubt its practical value. We ought, perhaps, to suspend our final judgment until Dr. Doubrava is in a position to describe the commutator by which the connections of the condenser are periodically reversed, but we are free to confess that our imagination does not at present extend to the possibility of constructing a practicable automatic device of this class suited for high-tension working.

Speaking of the employment of condensers in the commercial distribution of electricity, we may note that M. Jablochkoff took out a patent for this purpose in France nearly twelve years age; and a very curious patent it is. The inventor proposes to place condensers in parallel across a circuit carrying a high tension alternating current, and to put a Jablochkoff candle in series with each condenser. Now when M. Jablochkoff tried this experiment it seems that he obtained a better result than he had expected, and a result which was also better than that obtained when the candles were in direct circuit with the machine. This led him at the time to suppose that the condenser in some way obtained a supply of energy from the electricity of the atmosphere, and there is a good deal of what M. Jablochkoff now calls "this fantasy" mixed up with the specification. A copy of the specification which we recently received from the inventor has, however, been annotated by him in the light of more recent knowledge, and one of his notes is as follows:—"Pour ma part je l'explique par meilleur rendement des machines à courant alternative dans ce cas que dans le mode d'emploi ordinaire." Mr. Blakesley, who is the recognised authority upon this subject, could probably say whether upon theoretical grounds any such result might be looked for.

The Paper on "Underground Conduits and Electrical Conductors," read by Mr. J. Verity at the last meeting of the Electrical Engineers, afforded a good *résumé* of the present position of this momentous question. We suppose that the scantiness of the audience is partially accounted for by the fact that so many of the members had been dancing attendance all the week at the Westminster Town Hall.

One of the most serious troubles which has arisen in connection with the American conduits, and of which a striking illustration will be found in our American correspondence this week, is due to the leakage of gas and its consequent explosions. In the explosions which occurred last week in New York no personal damage was sustained, although the covers of the conduits which were lifted weighed about 1,600lb. The conduit itself sustained very little damage, and the men working in adjacent manholes were uninjured. All the same, explosions of this kind are decidedly objectionable, and we earnestly hope that the London gas mains are better laid than those in New York. This makes the tenth instance of the kind in New York alone. Even more serious cases have occurred in Chicago, Philadelphia and elsewhere. In one case a steam fire-engine was overturned.

In New York the manholes are brick-lined pits, usually about five feet square and eight feet deep. From manhole to manhole run rows of iron pipes embedded in concrete; the pipes are generally 2½in. or 3in. internal diameter and have screwed joints. The cables, most of which are about 2in. diameter, are passed through the numerous ducts thus provided, leaving a small portion open to the transmission of air or gas. The ducts may safely be assumed to be gas-tight, but the manholes, constructed of masonry, are far from being as impervious as the iron pipes. We also happen to know that in some cases gas-pipes have been allowed to pass through them—a practice which cannot be too strongly condemned. The top of the manhole is tightly closed, the inner lid being forced down by the central screw against a rubber gasket. But the tightness of the cover, which renders the accumulation of gas possible, makes the cause of the explosions a mystery. A mixture of gas and air can only be exploded by actual contact with fire; concussion is without effect; spontaneous combustion is impossible as far as known; external ignition from a cigar or match seems impossible on account of the tightly-fitting lid. The most obvious cause would seem to be an electric static discharge, but it is difficult to imagine how such a discharge could originate. In the present case it is alleged that no current was passing in any of the cables, and in another recent case the conduit contained nothing but telephone cables.

Under these circumstances it is rather startling to learn that in New York, on Tuesday, gangs of labourers, acting by orders of the Mayor, were chopping down the telegraph and electric lighting companies' poles, and removing the overhead wires from Broadway and Sixth-avenue, north of Union-square, and the connecting streets. Madison and Union-squares, with the immediate vicinity, were consequently left in darkness when night came on.

On Thursday and Friday last week Major Marindin conducted an inquiry on behalf of the Board of Trade, at Brighton, into the application for Provisional Orders by the Brighton and Hove Electric Lighting Company, which is opposed by the Brighton Corporation and the Hove Commissioners. The evidence, some of which is of an interesting character, will be found reported at length in this issue.

The appointment of Mr. J. C. Lamb to the position rendered vacant by the death of Mr. Patey as head of the Postal Tele-

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graphs Department is one that will command general approval in the service, and is especially gratifying to those who know Mr. LAMB personally. No better selection could have been made, seeing that he had acted as Mr. PATEY's colleague uninterruptedly from the date of the transfer of the Telegraphs to the Post Office in 1870. The vacant Third Secretaryship falling to Mr. JOYCE, Mr. LAMB is made an Assistant Secretary; but this is a position Mr. PATEY himself occupied for some time while controlling the Telegraph administration.

AT the Physical Society, on Saturday last, Mr. C. V. BOYS read a Paper on the insulating properties of quartz, which, it appears, are far higher than those of glass, while the former material has the enormous advantage of being practically non-hygroscopic. Since, moreover, the quartz when once it has been melted can be worked very much more easily than glass, this discovery of Mr. BOYS ought to prove of great value in the construction of electrostatic instruments. Every electrician knows the annoyance caused by the necessity of employing sulphuric acid to dry the air surrounding the insulating supports; for, if the acid is forgotten, the gradual accretion of moisture may make it overflow and ruin the instrument. Mr. BOYS stated that even if the quartz was dipped into ammonia, or boiled in a solution of potash, it only required washing with water to completely restore its insulating properties, and when it was raised to a red heat these properties were recovered on cooling. Some quartz, which the author kept for a considerable time in fused potash, did lose its insulating properties to a certain extent, as was to be expected; but even after this treatment the quartz remained a better insulator than glass.

IN connection with the recent very remarkable communication of Prof. OSTWALD in connection with the theory of electrolysis (*The Electrician*, March 1, 1889, p. 493), we would call attention to the views expressed by Mr. J. BROWN and Dr. OLIVER LODGE in the present issue. Prof. OSTWALD's experiment was, in fact, so very remarkable that it is almost a relief to hear that Dr. LODGE has failed to reproduce it.

We do not often sympathise with complaints which seek ventilation in Parliament, but the atmosphere of the Registered Letter Branch of the General Post Office deserves to be considered exceptional, for it cannot get ventilated either with or without Parliamentary aid. The condition of this and other branches of the Post Office when the gas is lighted is said to be almost insufferable. Mr. RAIKES replies that he has recommended the electric light for the whole establishment; but as he goes on to add that he has ordered the introduction of more ventilators, it would seem that he is not quite confident about the coming of the electric light. The delay appears to rest only with the Treasury, and for once in a way we recommend the half stifled employés of the Letter Branches to keep on agitating for the electric light, which they need even more than did those other Branches of the Postal Service who have long enjoyed it.

The Electric Light at Fort Augustus.—The electric light was installed last week in the Benedictial Abbey and School at Fort Augustus, on the Caledonian Canal.

Electricity and Building Operations.—An electric crane is now being used to raise material for some buildings now in course of erection at Brixton. The plant was installed by Mr. L. Fyfe.

Anglo-American Brush Corporation.—The Anglo-American Brush Electric Light Corporation have withdrawn from the Paris Exhibition, owing to their inability to get ready their exhibits in time.

Telegraph Line between Tonkin and China.—An agreement has been concluded between the French and Chinese Governments for the connection of the telegraph system of Tonkin with that of China.

Melbourne Exhibition.—We are glad to learn that Messrs. Felten and Guilleaume, of Mülheim-on-Rhine, have obtained the First-Class Order of Merit with special mention in the Electrical section of the Centennial Exhibition at Melbourne.

Suez Canal and the Electric Light.—The number of ships with the electric light which navigated the Suez Canal by night amounted last year to 1,611, against 395 for the year 1887 This is more than a third of the whole number. The average time taken by the vessels with the electric light to pass the canal is now less than 23 hours.

Northampton.—St. Andrew's Hospital, Northampton, is now lighted throughout by electricity. The plant comprises a 60 horse-power horizontal compound engine by Messrs. Galloway and Sons, two Galloway boilers of 50 and 35 horse-power respectively, and a 600-light Siemens dynamo. The light is much appreciated by the patients and staff.

The Deptford Station.—A 75-ton ingot has just been successfully cast at the Parkhead Forge, Glasgow. It is the first of a set of crank shafts for the London Electric Supply Corporation, and is 20ft. long. The shaft into which it is to be forged is 25ft. long by 36in. diameter. This shaft, with a 12in. diameter hole through centre, will itself weigh 23 tons when completed.

An Electric Tramway between Hemel Hempstead and Boxmoor.—Mr. Sellon, the engineer of the intended Chesham, Boxmoor, and Hemel Hempstead Steam Tramways, stated at a recent meeting of the Hemel Hempstead Highway Board that it was intended to commence the line between Hemel Hempstead and Boxmoor at once, and that a portion of the tramway would be worked by electricity.

A Laboratory for Amateurs.—A correspondent writes us to the effect that he has a small electrical library and laboratory in the north of London, and would be glad to hear of anyone willing to pay a weekly subscription for the use of the same. Should any of our younger readers be in want of some such facilities for experimental work, we shall be happy to place them in communication with our correspondent.

Galatz.—The municipality of Galatz are prepared to receive tenders for the lighting of the town either by gas or electric light. The tenders must be sent in by the 25th of May, O.S. (June 6), and must be accompanied by a deposit of 25,000fr. in cash or Government Securities. Applications in respect of this matter should be made in French or German. Specifications of the requirements of the municipality can be seen at the Municipal Offices at Galatz.

Electrical Coast Communication.—A pamphlet has been published, with the sanction of the Plymouth Chamber of Commerce, advocating the connection of our lifeboat and lighthouse stations along the coast by telephone or telegraph wires. Accompanying it is an admirable map, showing the contrast which the British coast presents compared with that of Denmark in these respects. It is published by R. White Stevens, Parade, Plymouth.

Ship Lighting.—We are glad to hear that Messrs. J. H. Holmes and Co., of Newcastle, have at present orders on their books for the lighting of no less than 16 steamers, in addition to an order which has just been received for a complete installation of the electric light on board a large passenger steamship now building by Messrs. Hawthorn, Leslie and Co. Messrs.

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Holmes and Co. have also numerous installations on hand in different industrial establishments.

Fulham Vestry.—At a meeting of this Vestry last week, the Law and Parliamentary Committee recommended that the application of the West Middlesex Electric Lighting Company to the Board of Trade for an extension of the time under the Electric Lighting Order Confirmation Act, 1884, be opposed, and that the solicitor to the Vestry be instructed to do so by every means in his power. After considerable discussion the Committee's recommendation was declared carried by a large majority.

Chatham.—A correspondent writes as follows:—"On Thursday last the subscribers to the Chatham Telephone Company were considerably startled by the continual ringing of the bells connected with the telephones. It was found impossible to stop the ringing and other noises which came from the instruments, and on an inquiry being made, it was found that in altering one of the telephone wires it had been placed slightly in contact with the electric light wires, and this caused the unusual disturbances."

Chester.—At the meeting of the Chester Watch Committee last week four applications were received to be allowed to establish stations in the city for supplying the electric light. These applications came from the Chester and District Electric Lighting Company, the Chester and District Electric Supply Company, Mr. H. E. Taylor, C.E., and Mr. R. Potts. A deputation from the first-named company waited on the committee and explained their proposals. The applications were deferred for consideration.

The Elliott Cresson Medal.—The secretary of the Franklin Institute has given notice that the Committee on Science and the Arts has recommended the award of the Elliott Cresson Medal to Edward Alfred Cowper, of London, England, and J. Hart Robertson, of New York, for their invention of a system of fac simile telegraphy, called "the writing telegraph." Any objection to the above recommendation on the score of want of originality in the invention should be communicated within three months to the secretary of the Franklin Institute, Philadelphia.

The Wehr Lightning Guard.—The Wehr lightning guard consists of a bell-shaped piece of zinc, which is in metallic connection with the line, and the upper portion of which has a series of vertical projections on its inner surface. Inside the bell-shaped piece of metal is a brass cylinder insulated by an ebonite disc: its surface is covered with horizontal flutings, and it is connected to earth by a U-shaped prong, which serves at the same time as a support to the whole apparatus. A ring of gutta-percha hermetically seals up the space between the zinc cover and the ebonite disc, thus preventing the introduction of dust and damp.

London County Council and Overhead Wires.—At a recent meeting of the London County Council, it was resolved:—"That as overhead wires, which are daily on the increase in the metropolis, are under no control whatever, the local authorities having no legal power to interfere unless actual obstruction or danger is proved, and as no means exist of identifying or dealing with ownerless wires, it is expedient that all overhead wires should be brought under legislation. That this Council should be constituted the authority for making bye-laws for the registration, regulation, and inspection of all such wires, and that it be accordingly referred to the Highways and Parliamentary Committees to confer and report as to the steps to be taken with this object."

Madrid.—"The failure of the Compañia Española de Electricidad, and the Sociedad Matritense, which was connected with it," writes the Madrid correspondent of *Industries*, "will have the effect of discouraging electrical enterprise in Spain. The industry here suffers partly from a want of technical knowledge, and partly from buyers wishing to buy very cheaply, and, in consequence, getting inferior articles. Very few electrical installations here are capable of doing what was stipulated in the contracts. The time is approaching when the contract should be made for the electric lighting and other electrical requirements of the magnificent building in course of erection for the Banco de España, which is to cost over £600,000.

A Power Station at Rheinfelden.—The three large Swiss firms of Zschokke and Co., Escher, Wyss and Co., and Brown, of Oerlikon, have, says *l'Electricien*, been studying the question of the establishment of a station at Rheinfelden for the distribution of power by electricity. The preliminary surveys have been made, the plans are already drawn up, and a concession from the Government of the Grand Duchy of Baden is now being applied for. The village of Rheinfelden is situated on the Rhine, about 15 kilometres from Basle, and the promoters estimate that about 15,000 horse-power will be available if modern hydraulic plant is installed. It is proposed to erect twenty 750 horse-power vertical turbines, coupled direct to as many 500,000 watt dynamos, giving 2,000 volts and 250 amperes. Several dynamos will be connected in series, and a series system of distribution will be employed.

West African Cables.—The cables for the West African and the Eastern and South African Telegraph Companies are now in process of being laid. Up to present date, the "Silvertown," belonging to the India Rubber, Gutta Percha and Telegraph Works Company, has completed the section between Bonny and Principe, distance about 202 cable miles. The "Scotia," belonging to the Telegraph Construction and Maintenance Company, has completed the cable between Cape Town and Port Nolloth, cable distance about 350 miles. The next section to be laid by the "Scotia" is between Port Nolloth and Mossamedes (distance about 1,172 cable miles), where it is expected she will meet the "Silvertown," when the latter ship has laid the Loando-Benguela (280 miles) and the Benguela-Mossamedes (250 miles) sections, thus completing an alternate telegraphic communication between Europe and the Cape of Good Hope *viâ* West Coast of Africa. This work will establish a complete line of telegraphic communication round the Continent of Africa, the first continent thus electrically embraced.

Electric Traction in Liverpool.—We understand that the directors of the Liverpool Tramways Company having carefully considered almost every available system of mechanical traction have decided to give a fair trial to the accumulator cars of the Electric Traction Company. Sir David Radcliffe, the chairman, and Mr. O'Neill, the manager, recently paid a visit to the Electric Traction Company's installation on the Barking-road section of the North Metropolitan Tramways Company, and after seeing the cars at work and inspecting the charging station, these gentlemen reported to their Board that this system was the best adapted for use on tramways, especially in the crowded streets of large towns, and arrangements have now been entered into between the Liverpool Company and the Electric Traction Company and North Metropolitan Tramways Company to supply a car for experimental purposes, together with the necessary electrical equipment, similar to those which are now running on the North Metropolitan section between Canning Town and Green Gate, Barking-road.

Electric Transfer Table at Altoona, Pa.—The Pennsylvania Railroad Company are using a Sprague motor equipment for the purpose of operating a large transfer table recently put up at their Altoona workshops. The armature shaft actuates the main driving shaft of the table mechanism through spur gearing. The motor is a 10 horse-power machine, and the current is supplied from a dynamo 600ft. distant. The weight of the motor is about 900lb. The speed of the table can be regulated from 100 to 300ft. per minute, according to the loading. The motor is suspended by springs on the end distant from the driving shaft of the table, so that the armature can rotate slightly, probably about one-tenth of a revolution, before the table starts. The table at Altoona is 60ft. long and 17ft. wide, traversing a distance of 295ft. The potential of the current used is 125 volts at the dynamo, which is decreased to about 110 volts at the motor. A table of this type is now being built by the Sprague Electric Railway and Motor Company for the Philadelphia and Reading Railroad.

The Proposed Telephone Convention.—A meeting of the committee formed to promote the holding of a Telephone Convention during the present year was held on Wednesday, 3rd April, at the Institution of Electrical Engineers, Colonel Jackson in the chair. It was resolved:—That it is advisable to hold a Telephone Convention at some time this year to be decided hereafter. That the Convention shall be formed of

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the managers and staff of the United and subsidiary companies, managers and staff of Post Office exchanges, foreign companies having offices in London, and such gentlemen as the committee may decide. That foreign telephone administrations and companies be invited to send delegates to the Convention. That manufacturers of telephonic appliances be invited to attend the Convention. That a sub-committee be formed, consisting of Messrs. Fletcher, Kingsbury, and Maier, to draw up the necessary circulars, and to attend to other business to be submitted to the general committee. It has been suggested to hold the Convention during the stay in London of the American electricians on their way to the Paris Exhibition. This will probably be early in August.

The Proposed Bermuda-Halifax Cable—Its Usefulness for Weather Predictions.—The announcement made by the British Postmaster-General, says the *New York Herald*, that the Government intended to lay a submarine cable between Bermuda and Halifax, will be good news to all Atlantic seamen and all American and European meteorologists. Bermuda is a natural observatory for watching hurricanes emerging from the tropical ocean and threatening to assail the United States or to advance north-eastwardly from the Gulf Stream into the transatlantic steamer tracks, and subsequently to burst upon the shores of Europe. Of course an observer at Bermuda cannot see with the naked eye what a Gulf Stream storm is doing, or determine by ocular demonstration what its course will be. But by watching the fluctuations of the barometer at this mid-Atlantic station, and by reporting them by cable to America and Europe, meteorologists on either continent will be enabled to feel the pulse of the storm and to determine more accurately its intensity and its future movements. For purposes of weather and storm forecasting in our Atlantic States, therefore, weather cablegrams from Bermuda will be invaluable.

Lighthouse Illuminants.—We (*Journal of Gas Lighting*) learn that there is a prospect of the inquiry in reference to lighthouse illuminants being reopened, with a view to a final settlement of the question at issue. The report on the South Foreland experiments of 1885, it may be remembered, failed to achieve that result. The most recently issued parliamentary papers on the subject include memorials to the Prime Minister from the leading shipowners at the various ports on the Clyde, the Tyne, and the Mersey, as well as at Dublin and Belfast, all expressing dissatisfaction with the South Foreland report. They propose that one of two courses should be adopted —either that a Royal Commission should be appointed to carry out further experiments in lighthouse illuminants, or that the criticisms of the recent report should be submitted to the judgment of independent scientific experts. As the result of an interview which Sir Michael Hicks-Beach lately granted to Mr. J. R. Wigham, whose system of gas illumination, it will be remembered, figured conspicuously in the South Foreland experiments, arrangements have, we believe, been made for the appointment of a committee, consisting of the President (Professor Stokes) and two Fellows of the Royal Society, to deal with the whole matter.

Conduit Explosions in New York.—The following paragraph was omitted from our New York letter of last week:—Quite a sensation was caused in this city on Monday last by a series of explosions in the subways in front of the Fifth Avenue Hotel at the corner of Broadway and Twenty-third Street. These explosions occurred just about midday, and the possibility of serious results will be understood when I state for the benefit of your readers who have never visited our city that the corner is just as busy and bustling a one as that at Oxford-circus. There were three or four explosions all within a few seconds of each other. The manhole covering and the heavy Belgium pavement, earth, &c., were scattered in all directions. A few hours later the place would have been thronged with ladies out shopping. As it was, there were plenty of them about, and one was thrown to the ground. A cab in front of the Hotel was overturned, and with it the cabman, and a messenger boy was blown up six feet in the air, attaining a greater rate of speed than he had ever reached before. The Subway Board took immediate action, notifying each of the five gas companies operating mains in the vicinity of the explosion that the accident had occurred, and asking them to take steps to prevent further leakage of gas into the subways. The general uneasiness of the public mind on this subject has not been lessened by another explosion down town in Liberty-street, where a huge escape of steam from the steam heating-pipes occurred, startling passers-by, and leading for a time to an interruption of traffic.

Electric Lighting Scheme for Weybridge.—Last Friday week a public meeting was held at Weybridge to consider the subject of the public lighting of the town. At a previous meeting a committee had been appointed to consider the matter, and Dr. Sealy now read their report. They had had before them three systems of public lighting—gas, oil, and the electric light. The Walton Gas Company offered to erect from 50 to 100 lamps for £2 per lamp complete, and to supply them with gas from October 1 to March 31, from sunset to midnight, at £1. 19s. 10d. per lamp. About 85 oil lamps of 35 candle-power, with posts, &c., complete, could be erected, lighted, and extinguished for 26 weeks, from dusk to midnight, all responsibility of breakage, &c., being borne by the contractor, for £295. A considerable desire existed in the neighbourhood for electric lighting. An offer had been received to erect the necessary plant and supply the lamps on the incandescent system at 45s. per lamp, the light thus supplied to be available during the summer as well as the winter months, from dusk to, say, 1:30 a.m. The Committee unanimously recommended this method, "being most in accord with the age in which they lived, as well as from every point of view most economical and desirable." After discussion, lighting inspectors were appointed, with power to make further inquiries, the sum to be expended by them to be limited to £230. We trust that the inhabitants of Weybridge quite understand what they have to expect from incandescent lamps employed for out-door illumination. We fear that to many of them an "electric light" is an arc light and nothing else.

Search Lights and Torpedo Boats.—The utility or otherwise of the electric search light for torpedo boat work was tested in a very practical manner in the recent night manœuvres of the Spanish torpedo boat flotilla, the result of which proved not only its utter inutility for search purposes, but that its employment became a source of danger to the boat using the light by reason of its showing her position to the enemy rather than *vice versâ*; and the result of a conference of the commanders of the various boats engaged in these night exercises was that the electric search light was entirely done away with on board these ships. The writer of the report states his preference for blue lights, Drummond rockets, &c. The experience gained with the electric search light when used from torpedo boats, therefore necessarily not placed high enough above the water, as set forth in the report, demonstrates the immense difference between its use in harbour and at sea. It was found that in harbour, when the beam of light was thrown on the fortifications, breakwater, and other objects at distances from 984 yards to 2,780 yards, they were clearly seen, even from the torpedo boats adjoining the one which was experimenting with the light, while at sea, and at the same distances, the land showed quite confused, nor was it possible to distinguish details. Throwing the beam of light out towards the sea for the purpose of discovering ships, the sea had the appearance of a brilliant fog; the low position of the light makes the beam extend over the water a long way, lighting up the water in which the boat is travelling and even the broken water made at the bows and passing the sides of the boat; further, the light is reflected from the deck, which is lighted by a luminous atmosphere which prevents anything being seen in the sector explored by the light, and still more so over the rest of the horizon, which is plunged in such obscurity that nothing can be seen. The electric light failed to discover a torpedo, landwards or seawards, though the position was approximately known. The electric light fixed the position of the boat using it. The fitting of the electric search lights prevented an object being rapidly focussed and its movements being followed if the object moved rapidly. The writer of the report attributes the difference of power in seeing objects illuminated by the electric search light in harbour and at sea as due to the influence exercised by familiarity with the region examined, and our experience agrees entirely with this view.—*Engineering.*

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ON OSTWALD'S EXPERIMENTS ON ELECTROLYTIC DISSOCIATION.*

BY J. BROWN, BELFAST.

An expression of opinion is asked concerning the experiments and theory of Prof. Ostwald as published in *The Electrician* for March 1st.

On p, 3 of the reprint, Prof. Ostwald "assumes that a solution of potassium chloride contains many free ions of $\overset{+}{K}$ and $\overset{-}{Cl}$."

To talk of "free" ions seems to me a contradiction in terms which would have met with the strongest disapproval of the originator of the word "ion."

In the very paragraph in which Faraday defines "ion" (*Exp. Res.* I., p. 197), he expressly repudiates, as implying too much, the names electro-positive or electro-negative as applied to substances "according as they go under the supposed influence of a direct attraction to the positive or negative pole," and his whole theory of electro-chemical decomposition implies that "the free substance cannot travel, the combined one can" (*ibid*, p. 157).

I submit that Faraday's definition should stand till we have clear experimental evidence to prove its inaccuracy, and I would respectfully suggest that if anyone wants to describe a "free molecule or atom, with a hypothetical electric charge, wandering about in a solution," he should invent a new name for it.

I do not write this from any pedantic regard for words, definitions, or authorities, but from a feeling that it is just possible there might be, in the polar or two-ended nature of the molecules of an electrolyte, some relation, deeper than has yet been discerned, with the polar or two-sided nature of the electric current accompanying their decomposition — "dissociation theories" notwithstanding; and it seems inadvisable to put this out of sight by altering the original meaning of the word "ion." Although Prof. Ostwald at first assumes the existence of "free ions," he concludes the description of his experiments on p. 494 with the remark, "This shows that the slightest motion of electricity in the electrolyte . . . cannot take place without a corresponding motion of the ions; it follows as a necessary consequence that the ions are free."

It is almost needless to point out that there are other ways of explaining the transference of substances in an electrolyte accompanying the movement of electricity (current) in it which do not imply "free ions," and are equally applicable to the experiment in question.

The explanation of Prof. Ostwald's arrangement seems simply this: The positive pole of the electric generator is connected to the tinfoil on A, and the negative through the earth to the mercury in C. A current passes till certain charges have accumulated on opposite sides of the glass walls of A, and is accompanied by the usual electrolytic phenomena, on which the experiment, so far as described, does not appear to throw any new light. It is, in fact, somewhat like a Lippmann electrometer, with a Leyden jar to be charged instead of a large surface of mercury to be polarised.

Prof. Ostwald attributes the observed effect to the influence of a "statical charge," but in both modifications of the experiment electricity in motion (current) is expressly mentioned as accompanying the phenomena.

It is difficult to see how the experiments are supposed to prove the particular hypothesis mentioned in the first part of the Paper, or why that hypothesis specially "explains" those experiments.

* A communication to the Electrolysis Committee of the British Association.

The Brazilian Submarine Telegraph Company.—The numbers of the Five per Cent. Debentures of this Company which are to be paid off on the 31st July next will be found in our advertisement columns.

ON THE DISTRIBUTION OF CONTINUOUS ELECTRIC CURRENTS BY MEANS OF CONDENSERS.

BY DR. STEPHEN DOUBRAVA.

The application of condensers in connection with electric lighting was first tried, for aught I know, by Jablochkoff. Afterwards the same idea was taken up by Gravier, who especially intended to use condensers for the distribution of continuous currents.

Without discussing the many objections raised against that principle of distribution, I intend to show in that which follows that condensers may prove useful for feeding incandescent lamps (of E.M.F.) in multiple arc, if continuous currents of a somewhat higher tension (200, 300, 400, 500 or more volts) are used.

The current obtained by charging and discharging a condenser is dependent upon its capacity, and upon the number of discharges per second. It does not matter what the resistance of the circuits (both of charging and of discharging) may be, provided they are not too great to prevent the condenser from being completely charged or discharged.

Let G (Fig. 1) represent the generator, the E.M.F. of which we may denote by E, supposing it to be constant. Now imagine the condenser being charged along the circuit $a\,b\,c\,d$, and afterwards discharged along another circuit $e\,f$ by means of any suitable contrivance.

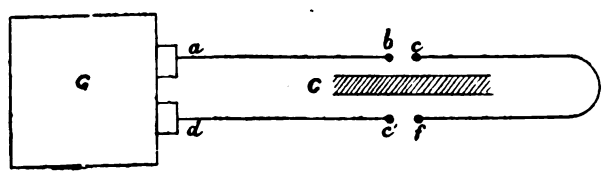

Fig. 1.

Let us consider first what happens during charging the condenser.

Be R the total resistance of the circuit $a\,b\,c\,d$,
L its coefficient of self-induction,
F the capacity of the condenser, and
P its potential at a certain time, t,
C the current at that time.

Then
$$R\,C = E - P - L\frac{d\,C}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Further
$$C = F\frac{d\,P}{d\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From (1) we obtain
$$R\frac{d\,C}{d\,t} + \frac{d\,P}{d\,t} + L\frac{d^2\,C}{d\,t^2} = \delta \quad . \quad . \quad . \quad . \quad (3)$$

and by substituting for $\frac{d\,P}{d\,t}$ the value from (2) we have
$$\frac{C}{F} + R\frac{d\,C}{d\,t} + L\frac{d^2\,C}{d\,t^2} = 0 \quad . \quad . \quad . \quad . \quad (4)$$

This equation will represent the course of charging. A particular integral of it is—
$$C = A\,e^{\alpha\,t} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and this, with (4), gives
$$L\,\alpha^2 + R\,\alpha + \frac{1}{F} = 0,$$

whence
$$\alpha = -\frac{R}{2L} \pm \sqrt{\frac{R^2}{4\,L^2} - \frac{1}{F\,L}} \quad . \quad . \quad . \quad . \quad (6)$$

The total integral of equation (4) will be therefore
$$C = A_1\,e^{\left(-\frac{R}{2L} + \sqrt{\frac{R^2}{4\,L^2} - \frac{1}{F\,L}}\right)t} + A_2\,e^{\left(-\frac{R}{2L} - \sqrt{\frac{R^2}{4\,L^2} - \frac{1}{F\,L}}\right)t} \quad . \quad (7)$$

The two coefficients A_1 and A_2 of integration may be easily found by resorting to the limits of the values of C and t.

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We shall now inquire about the amount of energy spent by the generator in charging once the condenser, and the relation of the energies in the charging and discharging circuits.

The energy given by the generator during the interval dt is $E\,C\,dt$, the energy spent in the charging circuit will be $\left(R\,C^2 + LC\frac{dC}{dt}\right)dt$, and the energy used in charging the condenser $C\,P\,dt$.

The complete charging will require a certain time τ, therefore

$$E\int_0^\tau C\,dt = \int_0^\tau P\,C\,dt + R\int_0^\tau C^2\,dt + L\int_0^\tau C\frac{dC}{dt}dt \quad . \quad (8)$$

The integral $\int_0^\tau C\frac{dC}{dt}dt = \frac{C^2}{2}\Big\}_0^\tau = \theta$, for the current is zero at both the times θ and τ.

$$\int_0^\tau P\,C\,dt = F\int_0^\tau P\frac{dP}{dt}dt = F\frac{P^2}{2}\Big\}_0^\tau = \frac{F\,E^2}{2},$$

P being θ and E respectively at the times $t = \theta$ and $t = \tau$.

In similar manner we get

$$E\int_0^\tau C\,dt = E^2\,F.$$

Therefore (8) will become

$$E^2\,F = R\int_0^\tau C^2\,dt + \frac{E^2\,F}{2} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

or

$$R\int_0^\tau C^2\,dt = \frac{E^2\,F}{2} \quad . \quad . \quad . \quad . \quad . \quad (10)$$

From this we see that the heat generated in the charging circuit equals the energy stored up in the condenser, and from the fact that the latter in discharging the condenser appears as heat in the discharge circuit, it follows that *the former quantity of heat must be equal to the latter.*

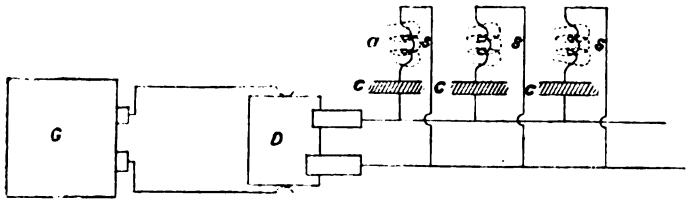

FIG. 2.

Therefore, considering the energy in the discharge circuit as useful work, there would be a loss of 50 per cent. of the whole energy absorbed in the charge circuit. But letting the two circuits coincide, it is seen at once that the whole energy may be rendered useful.

I will now proceed to show how such a system may be applied to the distribution of continuous currents.

The continuous current is conducted to certain points of distribution, where, by means of a peculiar disjunctor (the construction of which I cannot publish at present), it is reversed periodically. These reversals are used to charge condensers, in the circuit of which are placed induction coils; the secondary windings of the latter feed incandescent lamps. Fig. 2 represents the whole arrangements where G is the generator, D the disjunctor, C the condensers, S the inductors, and Q the lamps.

The area of a condenser necessary to feed a 16-candle lamp does not exceed one square metre supposing the E.M.F. of the generator to be 100 volts, and it can therefore be easily put in a small box. The inductor, too, is a very small one (some centimetres length), and may be applied directly to the lamp fittings. The cost of such a condenser and inductor (per 16-candle lamp) will be about eight shillings. By the arrangement described above I have already obtained an output of 97 per cent.

THE PHYSICAL SOCIETY.

At the meeting of this Society, held on the 13th inst., Mr. SHELFORD BIDWELL, F.R.S., exhibited

"A Lecture Experiment Illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel."

It is well known that nickel loses its magnetic susceptibility when heated, and that this loss occurs at a very much lower temperature than in the case of iron. This property is shown very neatly by a simple piece of apparatus designed by Mr. Bidwell. A small copper disc is suspended by means of two hooks and a pair of threads from a support, so that it can swing in its own plane, forming, in fact, the bob of a pendulum. A small bar of nickel projects on one side from the edge of the disc, and opposite to this nickel bar is a steel bar-magnet fixed in a horizontal position in such a way that when the nickel is in contact with the magnet the pendulum deviates slightly from the vertical. The copper disc is blackened in order that when heated it may cool again as rapidly as possible. When the apparatus is left to itself the nickel is attracted by the magnet and remains in contact with it. When the nickel bar is heated by means of gas flame, it almost immediately loses its magnetic susceptibility and ceases to be attracted; it therefore swings away from the magnet in obedience to gravity. By the time that it is swinging back towards the magnet it has become cool enough to have regained its magnetic susceptibility, and is therefore again attracted by the magnet, but it falls away again almost immediately owing to its being brought into the flame. Mr. Bidwell states that if the flame is kept steady the oscillation can be kept up for some ten minutes. It forms an exceedingly pretty experiment for lecture purposes. Mr. Bidwell then exhibited an experiment illustrating his recent discovery of an effect of light upon magnetism, which was shown before the Royal Society on March 21st, and described in *The Electrician* of March 22nd.

In the discussion which followed—

Prof. S. P. THOMPSON inquired whether Mr. Bidwell had obtained any data which would enable him to compare the action of light upon the magnetised bar with its effect upon selenium.

Mr. WHIPPLE stated that the late Mr. J. A. Broun had noticed a similar unstable state with regard to magnetisation in the case of a bar which had been demagnetised by placing it in hot water.

In reply to Prof. THOMPSON, the author observed that it was not generally admitted that the resistance of selenium was always increased by the action of heat, for, although this certainly occurred with some specimens, there was strong evidence that in other cases the opposite effect was obtained. It could not therefore be taken as a proved fact that the effects of light and heat on selenium were invariably of an opposite character. He had not obtained any data which would afford a basis for a numerical comparison between the action of light on the prepared bar and on selenium, but the suddenness of the primary effect, followed by its gradual increase, was exactly similar to what occurred in the case of selenium. In reply to another question, the author stated that he had endeavoured, by using a prism, to observe the action upon the bar, of light from different portions of the spectrum, but he had been unsuccessful hitherto, as the intensity of the light was insufficient to produce a sensible effect. He had, however, tried the effect of placing strips of glass of various colours in the path of the beam of light, and he found that the light from the red end of the spectrum produced more effect than that of the violet end, but this was only what was to be expected on account of the greater energy possessed by the rays from the former portion of the spectrum.

Mr. G. M. WHIPPLE then made a communication to the Society—

"On the Dark Flash seen in some Lightning Photographs."

The author referred to the fact that some two years ago the Meteorological Society had issued a circular asking for photographs of lightning flashes, and in reply to this circular a large number were received from different parts of the world, but chiefly from France and Belgium. Prints from these photographs have been pretty widely distributed, and have attracted considerable attention. It will be remembered that a great deal of interest was excited by the ribbon-like character of the markings observed in the photographs of some of the flashes, and still more by the so-called *dark flash*, namely, a dark mark on the surface of the photograph having all the characteristics of a lightning flash except in its being dark instead of light. Prof. Stokes had suggested that the dark flash might be caused by one flash following exactly the same path as another immediately preceding it, and having some of its light cut off, more especially the highly refrangible rays which would mainly affect the photographic plate, by having to traverse the nitrous oxide gas formed by the decomposition of ammonia during the passage of the first flash. With respect to the ribbon markings, it occurred to the author that they might be due to the photographs having been taken through the glass of a window. He had not yet had the opportunity of testing this by actually taking photographs of lightning flashes through interposed

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sheets of glass, but he had endeavoured to get an effect somewhat similar to that of a flash by drawing a wavy chalk line on a black board and photographing it after having previously interposed a sheet of plate or window glass slightly deviating from the plane perpendicular to the axis of the lens. These photographs, which were exhibited to the Society, showed a remarkable likeness to the ribbon markings observed in the photographs of the lightning flashes, and it seems probable that this may be the true explanation of them. It occurred to the author that the dark flash observed on some of the prints might have been due to a somewhat similar cause, namely, to internal reflection within the glass of the negative plate, and he pointed out how such an effect might be produced if the printing was effected by means of sunlight falling somewhat obliquely upon the negative. He had tried to test this by means of photographs of the chalk lines drawn upon the black board, but he had been unable to make many experiments owing to the recent weather having been unsuitable for printing. He showed, however, a photograph which exhibited, though not very perfectly, an effect of the kind.

In the course of the discussion which followed—

Dr. GLADSTONE said that though he naturally hesitated to criticise anything that Prof. Stokes had suggested as an explanation of an optical phenomenon, yet he found it very difficult to imagine that one flash should follow so exactly the same path as one which had just preceded it, and it also appeared difficult to believe that a sufficient quantity of nitrous oxide could be produced to show the observed effect. He stated that some of the photographs which showed the dark flash very clearly had been taken by a Mr. Shepherd at Westbourne-grove, so that the negatives would probably be available, and an examination of them would decide between the two explanations; for if Mr. Whipple's explanation was the true one, the dark flash would not be shown upon the negative.

Mr. BOYS stated that he always made a point of observing a lightning flash whenever possible, and that he had often observed a series of flashes following immediately one after the other in exactly the same path, every turn and twist in one flash being observed in those which followed it, and the whole series occurring in a fraction of a second.

Mr. C. V. Boys then read a note

"On Quartz as an Insulator."

He stated that when making quartz fibres by the process described by him some time ago of shooting an arrow carrying with it a kind of tail of softened quartz, he had observed that, when the fibres were very fine, if they broke off between the bow and the target the extremities assumed the form of a screw about half an inch in diameter and some eight or ten inches long. If any body were brought near this screw, the end of it would shoot out towards the surface of the body, retracting again when the body was removed. It hardly appeared possible that this could be due to any other cause than to the fibre becoming in some manner electrified during its formation. It, however, this were the case, it would show that quartz must be an exceptionally good insulator under ordinary atmospheric conditions, for otherwise the extremely minute charge which could be carried on so fine a fibre would be dissipated almost as soon as it was generated. It was, of course, quite impossible to obtain any direct proof of the existence of so small a charge beyond that given by the behaviour of the screw when any substance was brought near to it. He therefore determined to test the insulating power of quartz under ordinary atmospheric conditions, and he found that quartz is under any circumstances a better insulator than glass, and that under the ordinary atmospheric conditions there was no comparison between them. This was very well shown in an experiment which Mr. Boys exhibited to the Society. A pair of gold leaves had been suspended by means of a hook formed out of a thick quartz fibre, inside a case with glass ends, and had been electrified about five hours before the time of meeting. In order to make the conditions as unfavourable as possible, the air within the case was kept moist by placing a glass dish full of water inside it and the quartz hook was made very short. When the experiment was exhibited the deflection of the gold leaves had only diminished by about one-fourth of its original amount. If glass had been used as a support for the leaves the electrification would have been entirely dissipated in considerably less than a minute.

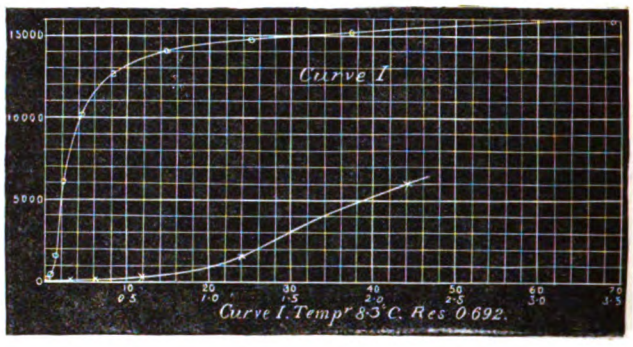
MAGNETISATION OF IRON AT HIGH TEMPERATURES.*

BY DR. J. HOPKINSON, F.R.S.

I have recently been making some determinations of the curves of magnetisation of iron at varying temperatures up to that at which the iron ceases to be magnetic. Although the experiments are still progressing, some of the results are of sufficient interest to be worth publishing briefly at once.

The method of experiment was identical with that which I used for a sample of nickel about a year ago. The temperatures are estimated by the resistance of a copper secondary coil, and, as there may be some uncertainty as to what temperatures the several resistances correspond with, I give in the curves which follow the resistance observed as well as the temperature estimated.

Curve I. shows the relation of induction to magnetising force ta the ordinary temperature, the resistance of the secondary coil

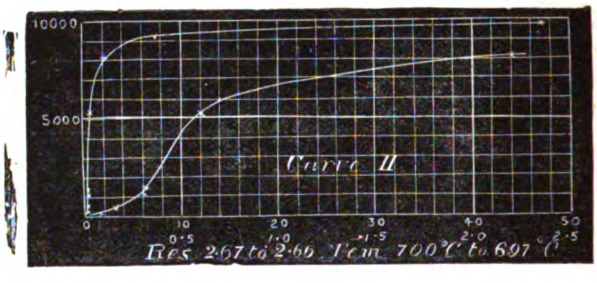


being 0·692 ohm. The curve is given to two scales, the scale of induction being the same in each, whilst the scale of magnetising force is magnified twenty-fold in the one as compared with the other.

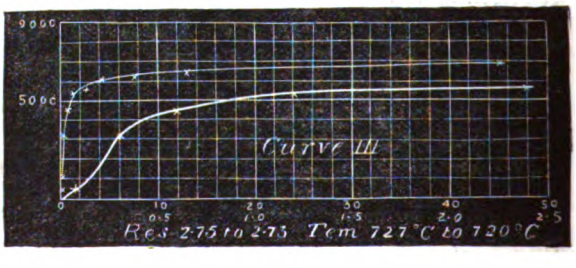
Curve II. shows the same relation for a temperature of 697° C. to 700° C.

Curve III. shows the same thing for a temperature between 727° C. and 720° C.

These curves illustrate what has been long known, that rise of temperature causes increase of induction if the magnetising force is small, but diminution of induction if the force is great.



In Curve IV. the abscissæ are temperatures, the ordinates are the ratios of induction to magnetising force or permeabilities for a force of 4·0 and of 0·3 C.-G.-S. units, the data being supplied from the preceding and other curves. The latter curve brings out a most remarkable feature. For this force the permeability increases somewhat steadily to a temperature of about 640° C.; its rate of increase then rapidly accelerates till it attains a maximum of 11,000 at a temperature of 827° C.; at 737° C. the permeability is practically unity or the magnetisability of the material has entirely disappeared.



Regarding the iron as made up of magnetic molecules, the axes of which are directed to parallelism by magnetic forces, the results are expressed by saying that the magnetic moment of the molecule diminishes with rise of temperature, at first slowly, but very rapidly as the point is approached at which magnetism disappears; on the other hand, the facility with which the particles are directed continually increases, at first slowly, but at high temperatures very rapidly. The effect is that at a temperature of 720° C. an exceedingly small force is competent to turn the axes of nearly all the molecules in a direction parallel to the magnetising force.

* Paper read before the Royal Society, March 14, 1889. Preliminary Notice.

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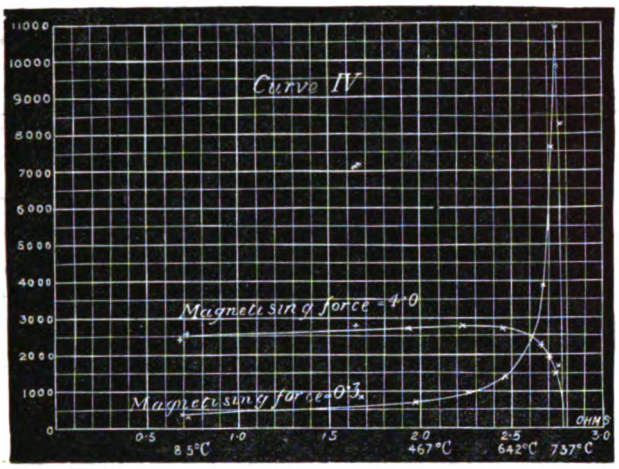
The estimates of temperature given herein must be accepted as provisional, and subject to revision. The actual temperatures are undoubtedly materially higher, as I have not yet taken into account the part of the secondary wire outside the furnace.

[If an iron ring which has never been magnetised has its curve of magnetisation determined for an ascending series of forces, if it be then thoroughly demagnetised by a succession of reversed currents of descending intensity and the curve of magnetisation is re-determined, I find that the two curves differ materially. The demagnetising currents do not reduce the iron to its virgin state. For small forces the second curve is below the first, indicating less induction for the same magnetising force; for medium forces the second curve is above the first, whilst for large forces the two curves agree.

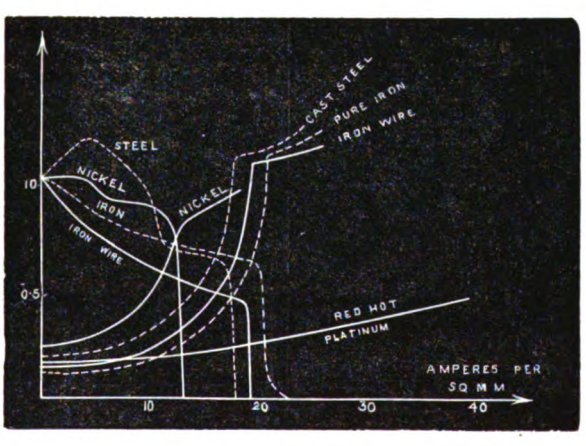


If a ring be heated with a current through the primary coil, and the heating be continued till the ring has ceased to be magnetic, if then the current be stopped and the ring be allowed to cool, I find that the ring is not entirely demagnetised by the heating, but that it re-collects its state of magnetisation before heating. It would seem that the magnetic molecules of the iron, having been directed by the magnetising force whilst they were magnetic, retain in part their direction when they have ceased to be magnetic by heating, and that when they again become magnetic by cooling its effect is apparent.—February 14, 1889.]

I have tested a sample of manganese steel, and find that at no temperature above the normal temperature does it become substantially magnetic.

THE ELECTRIC RESISTANCES AND MAGNETIC PERMEABILITY OF METALS AT HIGH TEMPERATURES.

In the *Annalen der Physik*, N.F., Bd. 33, will be found a short Paper by Prof. Kohlrausch on the relation between magnetic susceptibility and electrical resistance. Wires and strips of iron and nickel were enclosed in an air-tight zinc case, and treated by



passing through them currents of various strengths. The current passing was accurately measured, as was the E.M.F. at their terminals, thus determining the resistance of the wires at various temperatures. The pull exerted on the wire by a powerful electro-magnet of constant strength and at constant distance was also noted. The preceding curves, plotted from the results obtained, show that at that temperature at which permeability suddenly falls there is an equally sudden change in the temperature coefficient. The falling curves are those of permeability, the rising ones those of resistance. In the latter the ordinates for nickel are doubled and the abscissæ for platinum halved.

SOME ELECTRIC LIGHTING CENTRAL STATIONS IN EUROPE, AND THEIR LESSONS.—Part I.*

BY PROF. GEORGE FORBES.

Before commencing the subject of this Paper, I think it may be well if I give you some idea of the reasons why I have brought the subject to your notice. You are aware that great strides are about to be made at the present time in electric lighting in this country, especially by means of the Gaulard and Gibbs system with the converters put in parallel. To complete the practical details of such a system involves a large amount of experiment, and whether low-pressure or high-pressure work is in question, I have frequently maintained that a great deal of experience has still to be bought and time to be wasted. It has appeared to me that we can only hope to ensure the best success of electric lighting schemes now in hand if we bury our pride a little, and try to obtain the experience of foreign countries without paying for it or wasting time over it, as they have done. Some irresponsible persons have considered that I am much to blame for thus advocating the discussion, and consequent approval or disapproval, of systems which have been developed in foreign countries. I do not say that we are not even now capable of doing much better work than these countries, as we have done with steam, and I am certain that we shall do so in the course of time; but I do say that we are wanting in the experience, and I see all over the country work being done where the rules of experience have often been set at defiance; and my object in introducing this subject is chiefly for the second part of the title of the Paper, namely, a discussion of the lessons which can be derived from a study of the work which has been done abroad. The object of this Paper, then, is to raise a discussion on the details of central station lighting and electrical distribution, and to enter a protest against defective systems, which, without some such discussion, I feel sure will be as plentiful in the near future with us as they have been up to the present time.

Of course I am aware that many of my hearers have appreciated these points, and have, like me, tried to learn from those who have had most experience; and I know that they will pardon me for drawing attention to work that they have already examined, since they know as well as I do the need we have for such discussion.

I believe that my object can be best attained by proceeding, first, to describe the principal central stations in Europe which I have lately visited, pointing out specially the features in which they differ from the practice in this country so far as hitherto developed; and then to discuss the details, with a view of deriving the most profitable lessons from them as to what to adopt and what to avoid. I will deal only with what I believe to be the three most important central stations in Europe, namely, Berlin, Rome, and Milan. I have already partially dealt with America elsewhere.†

Berlin is supplied on the low-tension direct-current system, as originally developed by Edison, except the arc lights, which are on a high-pressure direct-current circuit.

Rome is supplied altogether, both for arcs and incandescent, on the Gaulard and Gibbs system, with converters arranged in parallel.

Milan is worked by Thomson-Houston apparatus for arcs, and by both low-pressure currents and high-pressure alternating currents for incandescent lamps.

At all the European stations which I have visited I received the same cordial welcome which I have always had in America, and the same desire that I should thoroughly inspect every part of the works. The stations have literally been placed at my disposal to watch the action of the machinery and to see what attention is required for its management. I have been allowed to interchange dynamos at will and generally to learn all that was possible. I must especially record my thanks to Signor Pouchain, Prof. Mengarini, Signor Trenza, Prof. Colombo, Mr. Lieb, Herr Rathenau, and Herr Datterer for the willingness with which they imparted to me so much information in the details of their working, and to Mr. Zipernowski and Messrs. Ganz and Co. for much valuable information.

BERLIN.

The Berlin mains are at present, I believe, supplying a larger number of lights than any other connected system of mains in

* Paper read before the Institution of Electrical Engineers, February 28, 1888. Part II. has already appeared in our issue of March 8.

† British Association, 1888.

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Europe. They supply 36,000 lamps of 16 candle-power and 144 arc lamps of 15 amperes. The conductors are all laid underground. A map is shown giving the position of mains already laid down and those in progress of construction. There are three central stations at work, and two more of improved type are in process of construction. The existing stations are—

1. Markgrafen Strasse.
2. Meuer Strasse.
3. Friedrich Strasse.

Those about to be added are—

4. Spandauer Strasse.
5. Schiffbauer Damm.

The first is the most important ; the third is quite unimportant. Here the boilers are by Steinmiller, and anthracite coal is used to

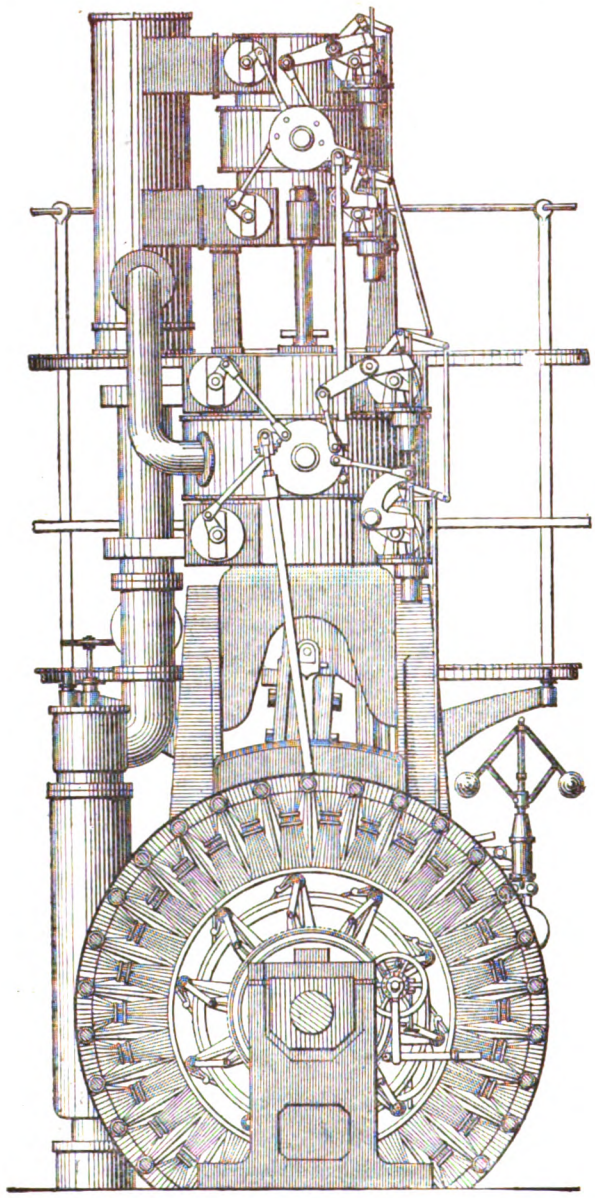

Fig. 1.—Engine and Dynamo, Berlin Central Station. (Scale 1 to 48.)

prevent nuisance from smoke. The foundations are of concrete in iron boxes built up with brickwork and cement. There are six engines of 160 horse-power each, each driving old-fashioned Edison six-legged dynamos. There are also four engines of 400 horse-power each, each driving a new type of dynamo direct at 80 revolutions per minute. These are compound tandem Corliss condensing engines by Van den Kirchove, of Ghent, who is one of the few foreign makers of engines who can compete with this country. The attached dynamos are by Siemens and Halske. The Electric Company of Berlin are also making a machine somewhat similar. A diagram (Fig. 1) is shown of this dynamo and of the engine combined, the height of which is 23ft. These continuous-current dynamos have never been built in this country, and are worthy of some notice. They may be described as multipolar Gramme machines, the poles being radial and the ring armature external to the poles.

There are ten poles on each machine. The armature is 3 metres in diameter, the commutator is 1½ metres in diameter. There are ten brush-holders. Each pair of poles and the corresponding part of the armature, with the corresponding pair of brush-holders, constitute a section which is virtually one machine. All these sections are joined in parallel. The field magnets are not seen in the drawing, being inside the armature. Two handles are provided, one of which adjusts all the brushes at the same time ; the other puts them on all together. Each brush-holder carries four brushes. A similar dynamo is being made by the Berliner Elektricitäts-Werke, in which the radial poles are external to the armature. I believe that this type of multipolar machine is a good design where the object is to get a large output with a slow speed. I hold working drawings in my hand of a similar design prepared by myself in 1881, but it was never executed. The number of bars of the commutator and the number of parts generally make it expensive to construct.

At this station the boilers are fed automatically by means of a hydraulic accumulator. The water for condensing is drawn from fifteen artesian wells which have been sunk for this purpose. Steam is used at a pressure of 115 lb., and it is claimed that 15·5 lb. of steam only are required per electrical horse-power. This is probably the most economical production of electricity for central station work in the world, and the engines and dynamos, though expensive, must certainly have a very low depreciation. The maximum work which this station can do is to generate a current for 26,000 lamps of 16 candle-power. It is found that the maximum number of lamps in use at any one time is about 66 per cent. of the total number of lamps.

The thing which strikes one most in this station is the enormous mass of copper. The conductors inside this station consist of eight strips of copper six inches wide and one-third of an inch thick. These are laid into the room for cable terminals. These strips, before entering this room, are interrupted by a gap, and a junction is made by punching seven similar strips, about 18 inches long, between the strips and the interrupted ends, the seven strips being placed between. Thus, in case of any serious accident, the whole of the mains can by one turn of the screw be disconnected from the dynamos, the interlapping pieces all dropping out. The only exception is in the case of theatres, where to prevent panic a separate connection is made with the dynamos. In the cable terminal room the positive and negative mains run horizontally and vertical rods come down to the different cables. There are eighty-four of these cables, forming forty-two pairs of feeders supplying the network of mains with current on the two-wire system. These cables are generally of large size, being frequently three inches in diameter complete. They consist of stranded cables covered with jute prepared with bituminous compound, enclosed in lead, then covered with tape and preservative compound, and finally armour-plated with two crossed spirals of iron ribbon. The system of feeders and mains is one of the features to which I wish to direct the special attention of English engineers, since the principle has been adopted of trying to produce as small a variation of pressure in the mains as possible. This is accomplished by having a large number of feeders. The cost of the underground cables has hitherto amounted to about £90,000, half of this being spent in mains and half in feeders. The greatest variation of pressure allowed in the mains is 1½ per cent. The loss of pressure in the feeders during periods of maximum supply is 15 volts.

The next point which I wish to draw special attention to in connection with the Berlin central station work is the type of cable which I have now described. This cable succeeded very well for three years, but lately they have been giving way very generally. The lead gets eaten into and water percolates to the copper, which is then destroyed. At first it was supposed that the deterioration came from the cable being pierced by the borers used by the gas people, but it was found that the same fault is produced even in iron pipes which have remained uninjured. It is supposed that the deterioration of the lead may be due in some way to its forming a galvanic element with the iron sheathing. Whatever the cause may be, the fact seems to be established that such cable will not stand underground electric light work for more than about three years. These cables generally run under the footways without any casing, and are connected by circular junction boxes to the houses, powerful clamps and no soldering being used for the contacts. All the dynamos feed direct on to the mains in parallel. One feeder alone, serving the mains close to the station, has a resistance in circuit in the station to equalise its loss of pressure to the others.

A few detached facts strike me as being worth noting.

Each 16 candle-power lamp uses 50 to 55 watts.

The charges for electric supply are 6s. per lamp per annum, and 9·6d. per Board of Trade unit.

The Aron meter is universally employed.

The price of gas in Berlin is 4s. 10d. per 1,000 cubic feet.

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The distances from central stations to lamps extend to 1,000 or 1,200 yards.

100 kilometres of cable have been laid on the two-wire system.

Each of the large machines can supply 3,000 to 3,500 lamps of 16 candle-power.

The largest cable is 1½ square inches of copper in section.

I spent a long time in this station, and had machines taken off and put on—an operation which occupied two or three minutes. I took careful note of the amount of skilled attention which was required, and saw that it was considerable. A man of high training, accustomed to the use of scientific instruments, is always in attendance and looking after the amperes and volts from the different machines and pilot wires and recording the measurements. It struck me that the working of this station was thoroughly German—certainly not American—but it was most methodical and very effective. One of the most interesting parts of this central station is the switch-board, with the special means for introducing a fresh dynamo in parallel or cutting it out. This also is a point to which sufficient attention has not generally been given in England. In all foreign stations that I have ever seen, when a current of over 100 amperes is switched in or out, it is found necessary to make use of an auxiliary load in the form of resistance, a banks of lamps being generally employed as being the cheapest resistance available. When a new dynamo is going to be introduced in parallel it is first worked on an artificial load, and the exciting current regulated until the volts and amperes agree with those of the other dynamos with which it is to be put in parallel. As soon as this equilibrium is attained the mains are switched into connection with the new dynamo and its load. After that the load is taken off. This prevents the possibility of the dynamo thus introduced being caused to run as a motor in the wrong direction by the current from the other dynamos, and prevents too violent a sparking at its brushes. The switch-board at this central station for the four large dynamos with the accompanying artificial load or resistance and with its ammeters and voltmeters is very perfect. Facing the operator, the switch-board is in four sections for the four dynamos. Each dynamo has three massive double-pole switches—one for the dynamo, one for the artificial resistance, and one for the mains. Plugs can be inserted for varying the resistance on the artificial load. The ammeter is placed above these switches for each machine, and a voltmeter can be attached to any one of them as required. A photograph of this switch-board is reproduced.

The second station is in the Mauer Strasse. This station helps to feed the mains for incandescent lamps. It also supplies arc lights arranged in twelve circuits all arranged in parallel, each circuit having twelve arc lamps of 14 to 15 amperes. Here three Siemens machines of the old type are driven by a counter-shaft. Three Siemens and Halske new-type multipolar machines are also at work, and four Edison machines and six multipolar machines of low tension. 11,000 lamps of 16 candle-power can be supplied besides the arcs.

Sixty-eight feeders, or thirty-four pairs, start from this station.

The Friedrich Strasse station is small, and was the commencement of the present system. Here four six-legged old-type Edison machines, each of 75 horse-power, are driven by Armington-Sims engines, and feed the general system of mains. Fifty-two men are employed on the three stations in eight-hour shifts. The Berliner Elektricitäts Werke paid last year a dividend of 5 per cent.; the Algemeine Elektricitäts Gesellschaft, which does the central station work, paid last year 7½ per cent. In special districts 800 to 900 lamp-hours per annum are used; in residences only 400 to 500 lamp-hours per annum. Load diagrams showing the current used at different hours of the day in each month and the proportionate cost from different causes, fixed and variable, have already been published (see *The Electrician*, June 29, 1888, p. 244).

Milan.

The central station in Milan is not of the highest importance, so far as we can learn anything about it, except on one important point. The principal streets throughout the whole town are lighted by Thomson-Houston arc lights to the number of 350. This lighting gives us some idea of the manner in which this metropolis will soon be lighted; and anyone who sees it and realises that this clear, white, brilliant illumination may be made to brighten our wider thoroughfares and to penetrate our darkest slums, will realise that when London is as far advanced in adapting these possibilities of civilisation as Milan is we shall lead healthier, happier, and purer lives, and our streets will be less notorious throughout the world as the hotbeds of immorality and midnight assassination.

I will briefly refer to the points which struck me as being most worthy of notice.

The station has 14,000 incandescent lamps of 16 candle-power. The maximum load is 60 per cent. of the number of lights installed.

At this station it has been found quite practicable to use Siemens ratchet arc lamps of only 4½ amperes, the upper carbon being 12 millimetres diameter and 200 millimetres long, the lower one 7 millimetres diameter and 200 millimetres long, lasting 7½ to 8 hours. For longer duration larger carbons are used up to 15 hours. This is the first station where I have seen an arc lamp of so low a current in use. A certain resistance is put in series with the lamp, and two lamps are put in series on the mains feeding the Edison lamps.

The La Scala Theatre has 2,800 glow lamps of 16 candles and 30 arcs on the same mains.

Edison meters are used and have given great satisfaction. The price is fixed on a sliding scale varying from 7d. to 1s. per Board of Trade unit. Gas now costs about 6s. 9d. the 1,000 feet. Before the electric light was introduced it was 10s. 6d. the 1,000 feet.

Two of the theatres are supplied by two Zipernowski machines, each of 40 amperes and 2,000 volts. For these circuits Siemens' concentric cables, of which a specimen is exhibited here, are used, the section being 28 square millimetres. Four Thomson-Houston machines are supplying 35 arc lights each, and four more are supplying 30. Half of these are single and half double carbon lamps, the single ones being put out at midnight.

I should mention that the coal used costs 27s. 6d. per ton, but labour is cheap.

Ten Babcock and Wilcox boilers supply the steam. The engines are all non-condensing. The low-pressure system is a two-wire system. Twenty-eight cables, or fourteen pair of feeders, supply current to the mains. No pilot wires are used, but a man reads the ampere-meter and sets the volts by a table. There are ten Edison machines of what is known as the Jumbo type feeding mains on the two-wire system They were originally supplied each with a separate regulator for adjusting the exciting current, but connecting gear has now been introduced which works them all simultaneously. A fan is provided for driving air through holes in the poles of the field magnets. The whole of the low-tension system is antiquated, and we have little to learn from it except what to avoid. I found the arrangements for switching dynamos in and out worked very well. An artificial load of lamps is used at one part of the room, a main going thence past each dynamo. Thus two men are required to put in a new dynamo. It is first put on to the lamps, the machine being excited to the same extent as the other ones. The load of lamps is changed until the volts are the same as on the working circuit. A signal is then given, and the dynamo with its load is switched on to the working mains. The load of lamps is then removed. This is simpler than at Berlin, owing to the fact that the exciting current is known beforehand, but less simple owing to the dynamo switches being distant from the lamps and voltmeters. Ten machines work thus in parallel without trouble, which is a very good performance.

At Milan the average cost for wiring houses is only £1 per lamp. Wages are one-fifth of the total working expenses, coal is one-half, lamp renewals (undertaken by the company) is 7 per cent. The capital is £120,000, of which £24,000 has been spent in mains. The company has paid a dividend for several years. It is steadily increasing, and was 4 per cent. last year. There is a large reserve fund.

(To be continued.)

LEGAL INTELLIGENCE.

United Telephone Company (Limited) v. New Telephone Company (Limited).

This was a motion treated as the trial, the defendants submitting to have a perpetual injunction granted against them restraining them from infringing, as to receiving instruments, Bell's patent, and as to transmitting instruments, Edison's patent, the plaintiffs not pressing for damages. The Attorney-General (Sir R. Webster, Q.C.), Mr. Aston, Q.C., and Mr. Micklem appeared for the plaintiffs; Mr. Bousfield for the defendants.

The ATTORNEY-GENERAL said he wished it to be known that the plaintiffs did not desire to press hard on persons who had purchased infringing instruments, and if such instruments were delivered up within a month the company would not proceed for damages against such purchasers.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

THURSDAY, April 25.

Institution of Electrical Engineers.

8 p.m. Ordinary General Meeting. "On Lightning Conductors." By Prof. Oliver Lodge, F.R.S. (Member).

FRIDAY, April 26.

Electro-Harmonic Society.

8 p.m. Smoking Concert at the St. James's Hall Restaurant.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 4 p.m.

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THE DIRECTORY for 1889 is NOW READY.

CONTENTS OF THE CURRENT NUMBER.

Notes 671
On Ostwald's Experiments on Electrolytic Dissociation. By J. Brown 676
On the Distribution of Continuous Electric Currents by Means of Condensers. By Dr. Stephen Doubrava. Illustrated 676
Physical Society—
"A Lecture Experiment Illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel" 677
"On the Dark Flash seen in some Lightning Photographs" 677
"On Quartz as an Insulator" 678
Magnetisation of Iron at High Temperatures. By Dr. J. Hopkinson, F.R.S. Illus. 678
The Electric Resistances and Magnetic Permeability of Metals at High Temperatures. Illustrated 679
Some Electric Lighting Central Stations in Europe, and their Lessons.—Part I. By Prof. George Forbes. Illustrated.. 679
Legal Intelligence—
United Telephone Company (Limited) *v.* New Telephone Company (Limited) 681
Meetings of Scientific Societies. 681
The Amalgamation of the Telephone Companies 682
The Board of Trade Inquiry on the London Electric Lighting Provisional Orders 683
Brighton Board of Trade Inquiry 686
An Arc Lamp for Amateurs. Illustrated 689
An Incandescent Lamp for Optical Purposes. Illustrated.. 689
American Notes 690
Berlin Notes 691
Correspondence—
Prof. Ostwald's Experiment in Electrolytic Dissociation.—Oliver J. Lodge..... 691
The Berlin Cables.—W. B. Sayers 692
Storage Battery Patents.—J. Irving Courtenay..... 692
Durtnall *v.* Shippey.—John Tadd 692
Patent Record 692
Companies' Meetings, &c.—
The Oriental Telephone Company (Limited)..... 693
Reuter's Telegram Company (Limited) 694
The Indo-European Telegraph Company (Limited)..... 695
New Companies Registered..... 695
City Notes, &c..... 695
Companies' Share List..... 696

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THE AMALGAMATION OF THE TELEPHONE COMPANIES.

In accordance with the arrangement foreshadowed in our issue of March 22nd, the three leading Telephone Companies have at length come to terms for the amalgamation of their undertakings, and if it obtains the sanction of the Postmaster-General probably the arrangement will quickly include all the minor companies who are still holding aloof. That such a combination was inevitable, or at least would be attempted, became evident from the moment the local telephone service began to develop into long-distance telephony. To be a reality the so-called trunk line service cannot be limited to the areas of several unequal and arbitrary districts, nor can it be interrupted at their boundaries. Working agreements are indispensable, and amalgamation follows in the natural course. Add to this the fact that the present representative of the Government Telegraphs has betrayed a somewhat hostile attitude towards them, the anxiety of the companies to combine for purposes of self defence is both prudent and proper. They are working under license from the Post Office, for which they

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pay an adequate royalty, and their present position is the natural outcome of privileges freely granted by one of Mr. RAIKES' predecessors in office. Mr. RAIKES evidently does not approve of the conditions, but he cannot repudiate them now; and it would be extremely unfair to cripple the legitimate development of their business simply because the telephone companies have been more enterprising than possibly Mr. FAWCETT ever supposed they would be. The wording of the original agreement reserves to the Post Office, we believe, the right to be consulted on any question of amalgamation among the companies. By giving its consent to the present proposal, the department will stamp with its approval everything that has been done or may be done in the way of trunk line extensions; and for our part we do not see how this consent can be withheld with due regard to the interests of the public, to say nothing of the rights of the companies. Whether they are acting wisely is another matter; but it can hardly be said that they have exceeded their bond.

How rapidly these trunk line extensions are being pushed may be seen from a few authentic details we are able to give in respect to the work now being carried out by the National Company, whose territory extends over the whole of Scotland, and in England includes the Northern and Midland counties as far as Birmingham, with the exception of the two minor sections held by the Lancashire and Cheshire and the Northern District Companies.

The National Telephone Company have recently connected Sheffield with Birmingham through Derby and Burton, taking in Nottingham with a loop on the way; and as Sheffield is in telephonic communication with Bradford, Leeds, Huddersfield, and other Yorkshire towns, Birmingham is thus placed in communication with all these towns. It is also possible to talk through the above system to Manchester and Liverpool. York and Harrogate are connected with Leeds; Skipton and Keighley with Bradford. An exchange has been opened at Grimsby, and the company is intending to connect Grimsby and Goole with Leeds as soon as possible, the work being at present in progress. The town of Hull will be similarly treated. The line between Birmingham and the National Company's boundary towards London is nearly completed, and as great progress has been made by the United Telephone Company with its portion, Birmingham will very soon be in speaking touch of London. It is confidently expected that as soon as the Birmingham line is completed conversation will easily be carried on between the Metropolis and the great manufacturing towns in the North. Manchester will be connected with London by extending the Birmingham-Wolverhampton line through the Potteries district to the Company's boundary, where it will be met by the lines of the Lancashire and Cheshire Company. In the extreme North of England Carlisle and Dumfries are being connected, and before long it may be expected that Dumfries will be linked through Ayr or Galashiels with the whole of the Scotch lines. From Harrogate the company purposes extending its trunk system to Ripon, which is within so small a distance of Stockton that it is not unlikely that the exchanges of the Northern District Telephone Company's system will soon be placed in communication with that of the National Company; whilst there is nothing to prevent Birmingham being coupled up with Worcester and Gloucester, and thus being brought into communication with the system of the Western Counties and South Wales Telephone Company.

Similar progress is being made by the other companies, tending to bring about a complete network of lines, so that uninterrupted communication may be available between them all. To avoid running up unnecessary wires nothing is more essential than that the several companies shall proceed on some united plan which will serve, and not more than serve, the requirements of the districts as a whole. With or without amalgamation this is what they ought to aim at and what they will have to rely upon in estimating their profits from long-distance telephony. It has yet to be demonstrated that long-distance telephony by itself can be made to pay; but it certainly will not pay if broken up into detached fragments. Great expectations are being raised, especially in the financial press, as to the future profits of these extensions, assuming, we suppose, that they will grow to be as widespread and as universal as the inland telegraph system. We shall be much surprised if the companies themselves take that view of their prospects, and they will certainly do well to feel their way cautiously, erecting lines only to such points as will either be directly or indirectly remunerative as feeders or adjuncts of the local services. With the command of the telegraphs to fill up the idle hours, a long-distance telephone wire might be made remunerative at high charges. But the telephone companies do not possess this advantage, and they will probably act with due circumspection accordingly.

In making these observations we have no desire to obtrude our advice on the Telephone Companies unasked for. They ought to know their own business best, and so far it is generally admitted they are performing it to the satisfaction of the community. When, however, we see the organs of finance speaking as if with the authority of the companies, and advising the public to invest their money in telephone shares on grounds which are extravagantly misleading, we may venture to interpose with a word of warning. Telephone shares may or may not be excellent for investment; but on the visionary prospects proclaimed by the trumpeters of the Money Market they would probably prove disappointing. The activity of the companies is taken as meaning so much additional outlay which the Government will be compelled to repay at a high premium. In reality the Government will be compelled to do nothing of the kind; and the best thing the companies can do during their brief period of existence—for they assume that it is to be brief—is to create a property which the Government will be glad to buy and be willing to pay a handsome price for. Still better would it be for the companies if they made the telephone service so complete and perfect in every way that the Government would let it alone altogether, neither buying it nor competing with it. The Government is not obliged to do the former; it is free to do the latter.

THE BOARD OF TRADE INQUIRY ON THE LONDON ELECTRIC LIGHTING PROVISIONAL ORDERS.

This Inquiry has been continued at the Westminster Town Hall since our last report. The following gentlemen represented the various parties concerned:—

Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham appeared for the London Electric Supply Corporation; Mr. C. A. Cripps for the Metropolitan Electric Supply Company; Mr. Moulton, Q.C., and Mr. R. S. Wright for the Chelsea Electricity Supply Company; Mr. Muirhead for the St. James's and Pall Mall Electric Light Company; Mr. Roger W. Wallace for the Notting Hill Electric Light Company, for the Kensington and Knightsbridge Electric Lighting Company, and for the Westminster Electric Supply Corporation; Mr. Moulton, Q.C., and Dr. Hunter, M.P., for the Electrical Power Storage Company; Mr. G. Prior Goldney (the City Remembrancer) for the City of London; Mr. T. Percy Gunyon (engineer) and two members of the Council for the London County Council; Mr. C. A. Cripps and Mr. F. M. Jenkins for the Strand District Board of Works; Mr. Hopwood (solicitor) for the Holborn District Board of Works; Mr. E. Bayley (clerk) and Mr. G. W. Thompson (surveyor) for the St. Olave's District Board of Works; Mr. James Spencer for the Greenwich District Board of Works; Mr. J. H. Horton for the Paddington Vestry; Mr. Hitchins for the St. George's (Hanover-square) Vestry; Mr. Wilkins (clerk) and Mr. W. Jenkins (chairman of the Lighting Committee) for the St. James's (Westminster) Vestry; Mr. Webster Murnane (clerk) for the St. Martin's-in-the-Fields Vestry; Mr. T. Eccleston Gibb

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(clerk) and Prof. Robinson, C.E., for the St. Pancras Vestry; Mr. Cripps and Mr. Greenwell for the Marylebone Vestry; Mr. H. J. Smith (clerk) for the Lambeth Vestry; Mr. Harrison (solicitor) for the Bermondsey Vestry; Mr. E. Moore (solicitor) for the Great Eastern Railway Company; Messrs. Payne, Son and Pollock (solicitors) for the North London Railway Company.

SATURDAY, APRIL 13.

Mr. R. E CROMPTON being recalled and further examined by Mr. MOULTON, said the difficulties met with in practically carrying out underground mains for the distribution of electrical energy are increased in proportion to the E.M.F. employed in the mains, and that whereas in America extended practice has shown that those difficulties are not insurmountable—in fact, are dealt with satisfactorily every day so long as the electrical pressure does not exceed 240 volts; that is to say, the limit of pressure generally employed on the Edison three-wire system—yet these difficulties are so great that they have not been satisfactorily dealt with when the pressure rises to 1,000 volts. He had already stated that the joints are the weak link in the chain of an electric circuit. As the number of the joints is increased the weakness is increased. It will be a matter of extreme difficulty to surmount those difficulties that will arise when 1,000 volts are used, and of course proportionately greater difficulty when 2,400 volts are used. In his own practice at Kensington he did not cut off the electricity in order to make connections—the pressure is kept in the mains constantly day and night. He did not see how it was possible with the high-tension mains for men to work making joints with 1,000 volts pressure on. He had tried all the ways that are known of running mains in pipes, and there are serious difficulties in the way proposed by Mr. Gordon of running several mains into one pipe. He had been obliged to discontinue it in his own case on account of the knotting and crossing of the mains. It is impossible to withdraw one main at a time in the way proposed by Mr. Gordon; it would be necessary to withdraw them as a whole, as the Post Office do with the telegraph wires.

Cross-examined by Mr. PEMBER: If it were necessary to take off the high pressure in the mains to make joints, it could of course be done when there was no working going on, but it would be an inconvenience to those who have the light taken off. He found practically the electric light is such a convenience to people who have dark basements, that they had a certain number of lamps constantly going. He had not been in America, but there was an official document stating that the arc lights with lots of joints in the mains working at 2,000 volts pressure were the reverse of satisfactory. The gentlemen in charge of them report that the cost of "up keep" is so great that they cannot earn a dividend. He had heard Mr. Ferranti's evidence as to the 2,400 volts pressure used at Nancy. Experience was that the trouble with joints only commenced after they had been made for some time. It would take some time to break the insulation down, but given the required conditions it certainly would break down. He believed he was in a fair position to judge of the merits of the transformer system; he was most anxious to be fair to the alternating system. He should unhesitatingly employ it for scattered districts under certain conditions, but for London he had always held the opinion that the concentrated nature of the lighting and the peculiar distribution of the areas of lighting are such as fit it particularly for the direct system employing storage. He had been in transformer stations and seen them working at Salzburg—a large station, rather larger than the Brighton station they had visited yesterday. As to the relative amount of coal consumed on the two systems, he had Mr. Ferranti's figures on the one hand and his own experience on the other, and he had compared them. He had calculated that his own lamps burned 1·1 hours a day. He was aware that Mr. Ferranti's evidence of the consumption of coal on the transformer system was on the supposition that the lamps were burned 10 hours a day; he simply said that was an impossibility—lamps could not burn 10 hours a day. Mr. Ferranti might have based his calculation of the consumption of coal on that 10 hours, but his own idea was that Mr. Ferranti made his calculation in the same way that he (Mr. Crompton) did. He did not think Mr. Ferranti thoroughly explained it in his evidence. Accidents had occurred at Vienna about two years ago, where some burnings-out took place—they were accidents with the direct system. A man put a plug into the wrong bar; the consequence was that although it was protected by what he considered a margin—what Mr. Ferranti would have called a 20 per cent. margin—still there was a good deal of copper thrown about. With regard to depreciation, he had always allowed 15 per cent. for cells in his calculations, but he found it was something less. Eighty per cent. had been the actual average return at the Vienna installations of the quantity generated—that is, deducting loss in the mains and loss of every kind.

Cross-examined by Mr. C. A. CRIPPS: He had no experience of 1,000 volt pressure transformed into 100 volt pressure, but he thought the reduction of pressure reduced the danger very much. He thought with a number of generating stations in comparatively small areas the Metropolitan was the best system, and that the best generating unit is about 200 horse-power. He considered the 2,000 volts in the charging mains the Chelsea were using was safe if kept completely separate from the houses. His experience was that for 100,000 lights of 10 candles 19 tons of coal would be consumed. As to percentage of cost of accumulators, if generating plant cost £200,000 the accumulator plant would cost short of £40,000 of that sum. That would give all the accumulator power he thought necessary—it would be about one-third of the total daily demand. The life of a lamp depends to a considerable extent on the variation in the source of supply, but it has been the case in a good many instances that he had investigated that leaks in the transformer had destroyed the whole of the lamps in one evening. The cost of the distributing mains under his system would be a little more expensive, not much, than they would under the alternating system. He thought it was about as £70 is to £100, taking his own at £100. Taking the absolute cost, the maximum cost of his mains are about £1,700 per mile, the minimum about £900, the largest proportion of the cost being that connected with the earthwork and the shifting of the other pipes and mains found in the line of route. He had actually laid down mains at the cost of £900 per mile—not a whole mile, but he had laid 900 yards at a figure which worked out to that. The average cost, however, was much in excess of that; it had worked up to in some cases £2,000 a mile. It was on the low-pressure system. He laid four miles in Kensington, and the figures he quoted were for representative portions of that. He used quarter-inch section of copper, which for 400 or 500 lamps is the utmost that could be used commercially; if on a short main of, say, two or three hundred yards, a larger number of lamps could be used. The voltage pressure through the quarter square inch for the three-wire system is 240.

Cross-examined by Mr. SHIRESS WILL: He based his condemnation of the alternating system for London on the fact that the cost of placing wires underground will be very great and will cause greatly increased expense. He had satisfied himself that even where it had been worked in England with overhead wires it had been a very costly system. His experience was, however, only second-hand as regards the alternating system. There were three ways in which electricity on the battery system could be supplied. First, a distribution of high-tension current to accumulators in each house; secondly, the distribution of high-tension currents to subsidiary stations, and then low tension from these subsidiary stations; and thirdly, having accumulators at the generating stations and distributing by low tension from those generating stations. The last is not the complete plan at Kensington; it is as Kensington is working now, because it is only on a small scale, but it is being extended to the three-wire system, where two batteries are arranged in series, part of them at home and part at distributing stations; so that it is a sort of intermediate plan between the second and third. The difference in the size of wire to carry 100 volts pressure and 2,000 volts pressure is very great; theoretically, the wire would have to be 400 times larger in the case of the lower pressure, but it is not so in practice. To carry a voltage of 2,000 they would probably put $\frac{1}{2}$ths copper down.

Cross-examined by Mr. WALLACE: The loss of 20 per cent. he had spoken of just before included all the loss—that is to say, the difference between what is generated at the dynamo and what the customers pay for at their own meters. Supposing a system of storage in which the whole current was put into the batteries and discharged, he had not formed an estimate of what the loss would be, but it would be greater than 20 per cent.

Cross-examined by Mr. HEWETT: When before the Special Committee of the Kensington Vestry he did not think the question was put to him as to whether he objected to bring their mains into the same conduit as other companies. Now that it was called to his mind he thought he had objected. He thought it would be necessary to have a subway provided for the four companies in Kensington if there was going to be open competition, but he did not think it would be practicable in High-street, for instance, knowing the small space there was. He did not agree to the small area to be allotted to his company and the Chelsea Company.

Re-examined by Mr. MOULTON: Theoretically, fuses are as perfect a safeguard for electricity as safety-valves are for boilers; theoretically, no boiler or steampipe with a safety-valve ought ever to burst, but as with safety-valves boiler explosions have occurred so with fuses he had seen nasty burns-out. In his opinion there are reliable meters for the direct supply—more reliable than for the alternating supply which have only recently been introduced.

Mr. FRANK KING called, examined by Mr. MOULTON, said he was the chief engineer of the E. P. S. Company, and as such had erected batteries and automatic distributing apparatus in the Chelsea District, the supply obtainable from which was 2,000 10-candle lamps. The batteries are separated into two distinct halves; each half is charged in series from the generating station; while the charge is proceeding to one half the other half is supplying what lamps may be required, and that process goes on until, when the two halves have been fully charged, they are both connected in parallel on to the supply mains to give the maximum output from the storage station. It would be quite impossible for the battery to be both on the charging and discharging main at the same time. The tension in the discharging main is 100 volts. The number of charging mains depends on the number of series; the voltage is 500. The charging main is not broken into at any place throughout the whole of its length. Taking into consideration the economical circumstances in the use of the plant, he believed the comparative waste in the transformer system and in this would be about equal.

Cross-examined by Mr. GRAHAM: There is one generating station in the Chelsea district and three distributing stations immediately proposed. The length of the charging main, which has to bear the tension of 2,000 volts will be about a mile and a quarter. The total current will be 375 amperes. The cells will be in groups of 53, each group giving out 75 amperes. There will be five groups. The weight of each cell is about 2½ cwt. Taking it at 2 cwt., the total weight of the cells would be 26 tons for 1,000 lamps. The cost of each cell erected, with stands and everything complete, is about £5; for 265 cells it would be about £1,325. The batteries can be maintained as things go for a depreciation rate equal to 12½ per cent. The battery at Lloyd's Shipping House, in which the company has a maintenance contract of 10 per cent., actually costs about 4½ per cent. —that has been running for over three years. There are 224 cells—about 400 lights—lighting for about 1,000 hours a year, roughly speaking. With regard to the practice at Chelsea, he had advised the Chelsea Company that they can supply the maximum current for seven hours per day, they having a capacity of ten hours. The depreciation he estimated under the circumstances of working the batteries at Chelsea would be 8 per cent. The positive plates would wear out, say, in three or four years. He had never seen a genuinely worn-out negative plate; he had seen them seven years old, but he would not say they would live for ever.

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Cross-examined by Mr. SHIRESS WILL: The Kensington-court station system is not the same as proposed to be used at Chelsea; the system at Vienna more nearly approaches it. The Chelsea Company would require at their sub-station 1,060 cells for 500 lights, taking 20 batteries. He would not be surprised to hear that at Kensington for the same number of lights they only used two batteries. He had heard the light had only been out once in Kensington for three years.

Re-examined by Mr. MOULTON: His company were prepared to take contracts as to the cost of renewals, repairs, and maintenance up to the standard of new at 12½ per cent., which would leave a fair margin of profit. He had made a calculation, and he found they could supply 100,000 lights, or any larger number, at £2. 8s. per lamp running. 100,000 lamps running would be 150,000 lamps installed. The actual capacity of the Chelsea batteries would be 10 hours, and it would be economical with that capacity to work for seven hours.

Examined by Captain CARDEW: Under the Chelsea system they had at each station two distinct halves of batteries, the two halves being capable of working together in parallel at, say, 3 o'clock in the afternoon. They are capable of working together at the maximum supply until 10 o'clock at night.

MONDAY, APRIL 15.

Mr. PEMBER addressed some remarks to the Inspector with reference to the duration of the inquiry. He feared that it was hopeless to think of finishing before Easter.

Major MARINDIN said his inclination was to begin again on the Wednesday following Easter Sunday; but perhaps counsel would consider the matter between then and Wednesday.

Mr. SHOOLBRED, cross-examined by Mr. MOULTON, said that as electrical engineer he had advised many corporations and local authorities, including Bradford, Carlisle, Liverpool, Norwich, Scarborough, &c. He was now carrying out a central station for the Bradford Corporation intended for house-to-house supply, and, after much inquiry and examination of installations, the direct current low-pressure system was decided on. His comparative estimate of cost was slightly in favour of the transformer system—one was £20,000 and the other £19,000, the £19,000 being in favour of the transformer. For the supply of Bradford he considered that the direct system, supplying not merely for light but power, and facilities for storage, was the better suited. When that was extended he considered it would be the most economical to add storage batteries to the system.

Cross-examined by Mr. PEMBER: His previous experience had extended over ten years, including installations at the Forth Bridge and Tate's Sugar Works. Those were for one building, and not brought foward as bearing upon central lighting stations; but the Forth Bridge installation had a considerable analogy with the central station. At the Forth Bridge there were difficult circumstances, constantly changing, much more varying than would be the case with a central lighting station. He had no experience yet of the alternating system. He had taken members of the Bradford Corporation to see the Kensington Court and the Grosvenor Gallery installations, and also the installation at Leamington. At the last there were 2,000 lamps run, a mile and a half of streets being wired. He thought that about 20,000 lamps were run at the Grosvenor Gallery at the time of the visit. The maximum supply from the Bradford machines was 1,800 amperes at 115 volts.

Mr. PEMBER asked for Mr. Shoolbred's Report to the Bradford Corporation, and it was decided to produce it later on.

Cross-examination resumed: The horse-power was 450 in three units, one being intended as a relief.

Mr. WALTER HARRIS KNIGHT (cross-examined by Mr. MOULTON) said he had been an examiner in the United States Patent Office in the class Electricity, and was afterwards with the Brush and Thomson-Houston Companies, and was there in connection with the London Subway Company. The tension used in the transformer system in America was 1,000 volts for the primary circuit. The insurance companies there required the transformers to be outside the houses. The points of inferiority of the transformer system were unreliability and the danger of burning out the transformers, its lack of economy when working on too small a load, and irregularity in the light. The efficiency practically got was 50 per cent.; it could be worked up to 95 per cent. efficiency. He thought it safe enough with 1,000 volts.

Is the shock from 1,000 volts alternating, in your opinion, a dangerous one?—Yes; the primary circuit is, of course, a dangerous one. I have had a friend of mine prostrate with paralysis from getting a shock of 1,000 volts alternating.

WITNESS continued that in his opinion the joining of the mains would be a source of weakness; underground, with high voltage, it was an extremely difficult feat to perform, even when the current was off. He had never known it done with the current on; but with it off it was difficult to get a homogeneity between the insulator that is already down and the insulator to be put in. He had seen the Westinghouse alternating motor and the Thomson-Houston alternating motor, and he had invented one himself, but as a matter of practice it was impossible to get any efficiency worth speaking of, and their durability was extremely uncertain. They burned out under over-load, and they would not respond to the load like the direct-current motor by drawing more current as the speed went down. The Thomson-Houston Company, after spending a deal of money on them, had given them up, and were now more extensively engaged in direct-current motors than anybody else in America. That company was now doing the largest electrical business in America, about equally dividing the alternate current business with the Westinghouse Company, there being an alliance between them. With regard to the working of alternating dynamos for parallel, that had not been practically done in America at all.

Cross-examined by Mr. C. A. CRIPPS: When he was speaking about the lack of economy in the alternating system the generating unit he had in his mind was small—there was none in his country over 100 horse-power. Mr. Young, the gentleman whom he had mentioned as being paralysed, met with that accident by placing his hands on the terminals at the switch-board.

Mr. PEMBER: Was that done with a concentric tube?—No.

Cross-examined by Mr. SHIRESS WILL: Have you had any experience of underground wiring on the alternating-current system?—Not personal experience; I have seen it.

Mr. JAMES SWINBURNE, examined by Mr. R. S. WRIGHT, said that the cost must eventually come upon the consumer if there were several companies in the same district. The effect of "pirate" companies would be very disastrous, because a company like the London or the Metropolitan would, by virtue of choosing all the most paying points in town, be able to undersell, he would say, the Chelsea in Chelsea, and that would hold even although it subjected itself to the compulsory clauses in Chelsea, because it would have such a great advantage in the other parts of London. He thought they would be able to turn their attention to district after district, and starve out every other company in turn. He did not think that electricity was on the same footing as gas when the Gas Acts were passed, because electricity would now have to compete with gas, which had already had its mains everywhere, and there would be no question of monopoly in giving one electric company a district to itself. The competition of gas was sufficient. With overhead wires the alternating system for scattered towns, with a transformer for each house, was a very splendid way of lighting. In Boston electricity was cheaper than gas—gas being 10s. a thousand cubic feet. The direct system was used generally without accumulators, there being some question about the patents. He was very doubtful as to whether the insulation proposed for the Deptford scheme would be perfectly safe; the paraffin wax was liable in time to become full of minute cracks. If electrolytic action commenced it would break down the insulation altogether, and would cause a leak from one side to the other: a leak in a tube with 10,000 volts and 300 amperes or more capable of flowing, might be a very serious thing—it would probably throw melted copper about. The same objections about leakage and loss applied to the Metropolitan as to the London Electric, and there might be troubles of interference with telephones arise from the Deptford scheme. The proposal to earth the main at Deptford gave rise to trouble in many ways. He thought they should not be earthed at the Deptford end. If the telephones were interfered with the Post Office might at any time veto the whole system.

Cross-examined by Mr. PEMBER: He did not like to differ from Sir William Thomson on the point, but he was there to give his opinion.

Mr. THOMAS O. CALLENDER, examined by Mr. R. S. WRIGHT, stated he was the manager of Callender's Bitumen Telegraph and Waterproof Company at Erith. They had manufactured and laid mains for some hundreds of installations. He had had special experience in relation to asphalte paving, and the difficulties of opening, laying, and restoring it. In London, especially the busy parts, all the space under the streets is occupied by gas and water pipes, and the Post Office tubes are running nearly everywhere now. You could not lay your mains close up to gas and water pipes, as the gas and water companies require a sufficient space to be left at the unions in a pipe, so that men can comfortably get their hands and arms down. He thought the proposal of the Metropolitan Company to lay a number of mains in one tube would be a great mistake—there would be very great difficulties when you came to draw them out. His company is a large shareholder in the Chelsea Electricity Supply Company, one of his directors being a director in the Chelsea Company. His company have the contract for the supply and laying the whole of the Chelsea cables. The total amount of the contract is £7,000.

Cross-examined by Mr. GRAHAM: Probably, some part of the payment for the work done by his company for the Chelsea Company would be in shares, perhaps half. As he had said before, he was running 2,000 volts; he had never run 10,000; he did not know anything about 10,000; 2,000 could be quite comfortably worked for charging. He would certainly not use the same sort of cable for 10,000 as for 2,000. He thought 10,000 would be done eventually, but he would not like to do it now.

Mr. J. S. RAWORTH examined by Mr. R. S. WRIGHT, said he was superintending engineer of the Anglo-American Brush Electric Light Corporation, and one of the Committee of Engineers of the Chelsea Electricity Supply Company. The Chelsea Company have erected a building at Draycott-place, 127ft. long by 41ft. 10in., with a basement for engineer and boiler purposes, with two boilers already fixed and working. The ultimate capacity of the station will be 12 or 13 storage stations each of 2,000 10 candle-power lamps. 100 volts; a total capacity of 26,000 lamps in use. On Mr. Crompton's estimate it would be 52,000 lamps fixed, the relation between lamps fixed and lamps used being usually two to one.

Cross-examined by Mr. PEMBER: The Brush Company are large share holders in the Chelsea Company, but he was not aware of the fact sufficiently to justify him in saying that the Chelsea Company is taken over by a syndicate composed of the Brush, the Callender, and the Electric Power Storage Companies. A part of his contract had been paid for in shares of the Chelsea Company.

Cross-examined by Mr. LYTTELTON: The cost of his part of the Chelsea Company's installation, consisting of engines, boilers and dynamos, is £6,500, which is for three battery stations. Some proportion of the amount may be paid in shares at the option of the directors of the Chelsea Company. They can pay all in shares if they like.

Cross-examined by Mr. SHIRESS WILL: They proposed to work entirely from the batteries—that is to say, in the early part of the day they charge up the batteries first one-half and then the other half, then when the heavy part of the lighting comes on, say, at three o'clock or five o'clock or six o'clock, according to the time of the year, they stop the engines and put both the batteries in parallel and work on to the lamps, and that continues during the whole of the night, the engines being stopped absolutely.

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They would not put down the transformers until they had got to the limit of the working capacity of their batteries, which might be in the course of two or three years. It is a continuous-current transformer.

Major-General C. E. WEBBER, examined by Mr. R. S. WRIGHT, said he was the managing director of the Chelsea Electricity Supply Corporation, and was for nine years division engineer under the General Post Office for the east and south of England, including the metropolis, during which period he had charge of the maintenance of very many miles of underground lines of electrical conductors for the telegraph service. In 1883 he drew up a scheme for electric lighting distribution for the north-east part of the parish of Chelsea. In the same year he patented a system invented by himself of laying large copper conductors in iron cases. In 1884 he and other gentlemen associated with him purchased the present site of the central station in Draycott-place, and formed a company, or rather syndicate, as it was called in those days. In June, 1885, after his return from Egypt, statutory notices were issued for a Provisional Order, the Vestry approving, which was granted by the Board of Trade, and confirmed by Parliament in September, 1886. The original area of supply was in the Hans Ward of Chelsea, and included 660 houses. One calculation has been that about one-third of those will ultimately take the electric light, and that each house will require an average of 27 lamps, making 6,000 in the district, for which they would have to provide 12,000 installed. Under this order we ask leave to add the lower Sloane-street area of about 122 houses. Estimating one-third of these to be consumers it would require 1,080 lamps to be used, or 2,160 to be fixed. Then the Upper Sloane-street division is also applied for with 135 residences, which works out at the same calculation, 44 estimated consumers, 1,190 lamps to be in use, 2,400 roughly to be fixed. Then in the Kensington district, 400 residences, 133 estimated consumers, 7,000 lamps to be fixed, 3,500 in use; and in the area of St. George's, Belgravia, 1,536 houses, 512 estimated consumers, 13,860 lamps in use. As regards the capital, the central station at Draycott place with engines and fitting up will cost about £30,000. The three Chelsea stations proper, Hans Ward, Lower Sloane-street, and Upper Sloane-street together, will cost a further £24,000; Kensington £12,000, and St. George's £42,000. The whole cost comes to something like £108,000, which includes mains and everything. He would like to say that the inhabitants of the district where he lived, in Egerton-gardens, were very anxious to have the light. himself among the number, and a petition had been signed by them to the Board of Trade asking that the recommendation of the Kensington Vestry to grant a license to the Chelsea Company might be carried out as soon as possible, so that they might have the light, and he would propose to put in that petition. Since the Act of 1888 removed the difficulties about the capital, they had found themselves in a position to secure more than the capital necessary for starting the works. The figure of gross earning per lamp, which he had studied in all parts of Europe, varied enormously, but the average earnings of 27 lamps per house would be less than £27—it would be between £20 and £27 gross earning. He calculated that when they were supplying 10,000 lamps in use, running the maximum number at the busiest hour, they ought fairly to earn a net profit of 10 to 12 per cent., available for payment of dividends. There has been no promotion money paid of any kind—no preliminary expenses. Many people put the earnings of a lamp at 20s. year, he put it at about 17s. or 18s. If the London Electric order is passed the effect would be that the Chelsea Company would have a very unwelcome bedfellow, and the streets would be taken up by a second company over that area which Mr. Callender described as being nearly completed with its mains, and it would affect the value of the shares of the Chelsea Company. He had heard what had been suggested by somebody, that several companies should have their mains all in one tube, and that each company should draw out its own main when it was wanted. He thought that was simply folly.

The examination of the witness was not concluded at the adjournment of the inquiry till the next day.

(To be continued.)

BRIGHTON BOARD OF TRADE INQUIRY.

A Board of Trade inquiry with regard to the application of the Brighton Electric Lighting Company for a Provisional Order was commenced at Brighton on Thursday last by Major Marindin, C.M.G., R.E. Mr. F. J. Tillstone (Town Clerk), Mr. Lockwood (Consulting Engineer), and Mr. Boxall appeared on behalf of the Brighton Corporation; Mr. Roger W. Wallace appeared for the Hove Commissioners; Mr. J. W. Howlett represented the interests of the Brighton and Hove Gas Company; and Mr. Shiress Will, Q.C., represented the promoters of the Company.

Mr. WILLS, Q.C., said that he represented a company who had been for several years past supplying electricity in Brighton, and he thought they would be satisfied that considering the limited powers they had and the necessarily limited nature of their operations and of their works, they had been doing so with great advantage to the town. A number of private houses and hotels, he said, were being supplied, and generally it would appear that satisfaction had been given. Objections had recently been made to the overhead wires, and a Board of Trade inspection was held by Colonel Armstrong. After referring to the report of the examination made at that time, counsel stated that it was recommended that application should be made to the Board of Trade for a Provisional Order, so that the company might have power to carry their lines underground. A letter had been received from the Board of Trade on the subject and application had been made. He was sorry, however, to state that they had not been able to gain the consent of the Brighton Corporation nor of the Hove Commissioners, but he hoped nevertheless to be able to satisfy them on that occasion. Allusion was next made to the obtaining of a Provisional Order by the Brighton Corporation for the supply of electric light in a specified area as was shown on Schedule A, and which did not cover the whole of Brighton. Without entering into any controversy as to the reason why the Corporation scheme was not carried out, he would say that they had done nothing towards lighting that compulsory area. They had it, he understood, in the Pavilion and several other places, but not in the area for which the order was applied for. He took it that the Brighton Corporation had been very anxious to be careful with the ratepayers' money, and rightly or wrongly they had taken the view that the system of electric lighting was of an experimental character. Continuing, he assured those present that the company he represented desired no monopoly, and observed that the order they wished to apply for would provide that all new mains should be laid underground. Further, they asked for five years in which to remove the overhead wires, and he hoped after the evidence had been given that they would be better able to judge of the matter. Another thing he wished to call attention to was that they were not bound to have any particular system supplied, and they would be free to adopt as a company any system which science might prove advantageous both for commercial and other purposes. The objections of the Hove Commissioners were almost confined to the clause stating "that the description of the proposed works was insufficient, and the provisions for securing the safety of the consumer and of the public inadequate," but in answer to that he would say that the company were under the orders of the Board of Trade from time to time. The objections of the Gas Company principally had regard to clauses 11 and 12, but in those clauses the company were following the forms authorised by the Board of Trade. As to the Telephone Company their objections had been met. After a lapse of seven years the Electric Light Company would be prepared to bind themselves to a standard price fixed on a sliding scale as in all new gas companies. They wished to act in a fair commercial spirit, knowing that in satisfying the town they were considering their own interests. Mr. Wills then called

Mr. ROBERT HAMMOND, the Chairman of the Brighton and Hove Electric Light Company, who said that he had been chairman of the company since it was started in September, 1885. The company on its formation took over an existing concern, which had been going for about four years previously. House-to-house electric lighting had therefore existed in Brighton since 1881. The company had supplied electricity by means of overhead wires, and had been prepared wherever way leaves were obtainable to supply electricity in Brighton and Hove for house-lighting, hotel-lighting, or any other purpose. The company had lighted the station during the whole time. Up to the present the Brighton Company had no powers to lay wires underground, but they desired to have them, as they believed that they could greatly improve the lighting if they had them. There were over twenty miles of overhead wires in Brighton, the area in which they existed being bounded by King's-gardens, Hove, on the west, Belgrave-place, Kemp Town, on the east, and Hanover-crescent on the north. The station of the company was in Gloucester-road. They received a letter from the Board of Trade on November 6, enclosing a report by Colonel Armstrong, asking whether the directors were prepared to take the necessary steps to comply with his suggestions, and calling the attention of the directors to the serious responsibility they incurred by supplying electricity under the system described in the report. The main objection raised by Colonel Armstrong to their system of overhead wires was that they were not covered with proper insulating material, and in certain places they were not running parallel, and therefore did damage to the Telephone Company's wires by induction. On receipt of that letter and report, the directors at once placed themselves in communication with the solicitors of the Telephone Company, and agreed that they would change their wires in such a way as not to interfere with the telephone wires. They entirely removed the objection, and the Telephone Company sent a cheque the other day for a portion of the cost, and expressed great satisfaction with the present state of things. In giving five years as the period they would take in converting the overhead wires to underground they had adopted the extreme time, and would undertake to make the change in three years. The company desired to run the wires underground because they could use cables of a thickness that they could not run overhead. They would be able to give better light and to regulate it better. Their price during the last few years had been 1s. per Board of Trade unit. With the very large increase of plant which this order would enable them to put down they saw their way to a great reduction in price, and they proposed to base their prices on the consumption, according to a sliding scale of 1s. per unit, 9d. per unit, and 6d. per unit, so that clubs, hotels, and large consumers would get their electricity at something like 7d. per unit. Where the light was required over three hours a night it would be supplied on the sixpenny scale, or at an alternative charge of 8d. per unit all round; 6d. per unit was equivalent to about 4s. in gas. The company were not asking for any monopoly, and were making their application in full knowledge that the Corporation had their Provisional Order of 1883. They proposed to limit the dividend after seven years; they said seven years, because with the present limited number of electric light supply companies in the country it was impossible to fix a fair price, but the experience of seven years, they thought, would enable them to determine. At the end of seven years, under the order, the price would be fixed by arbitration based on a 10 per cent. dividend, power being given them to increase that dividend with every reduction in price. The system now in use by the company was the alternating-current parallel transformer, which he had found to work well, not only in Brighton but in Eastbourne and Kensington as well. The Brighton Company had so far paid. Their standing charges had been enormous compared with what they would be if they had a larger plant and could supply a larger number of people. The same electrician could manage a place five or ten times as big as the present station. Notwithstanding these disadvantages, they were the only Electric Light Supply Company in England that had regularly paid its shareholders from the beginning and put aside a sufficient

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reserve for depreciation. Before the company was formed an immense amount of money was spent in experiments, and this did not appear in the balance-sheet. They had occasionally received congratulatory letters from customers.

Mr. WALLACE: I think perhaps it would be as well if Mr. Hammond put in the letters of complaint as well.

Mr. HAMMOND: I haven't those with me. Proceeding, Mr. Hammond said they admitted that their light had not been perfect, but any defect was due to their works being so cramped. The demand in Brighton for electricity was increasing, and the average increase in their business on the year was 41 per cent. The increase on the quarter just ended, as compared with the corresponding quarter of last year, was 81 per cent. Up to the present they had been able to cope with the demand, but could not put down any more machinery.

Cross-examined by Mr. BOXALL, witness said that there was no provision in their Provisional Order for the appropriation of any specific sum by way of capital, nor was there provision for any deposit, but they would be pleased to put in clauses to that effect, and also a clause for revocation in case the capital was not subscribed in a certain time. Up to January of this year the nominal capital of the company was £25,000, but only £12,500 had been actually issued, and £3,100 of that was issued during 1888. Up to the end of 1887 they had fifteen miles of mains open, and they added over five miles during 1888. They gave notice of their intention to apply for a Provisional Order so far back as June, 1888, and, notwithstanding that they contemplated the application, they continued to increase their overhead mains, as they were not certain of the application being granted. By the Provisional Order they would be compelled to put all their present circuit underground during three years. The undertaking taken over on the formation of the present company was the Hammond Electric Light Company. He did not know at what amount the works of that company were put down in the liquidation. His impression was that the works cost £10,000. When that company went into liquidation he and others bought the Brighton branch for £2,000, and re-valued it at £6,000 in issuing shares, as in the meantime they considered they had spent £4,000 upon experiments in connection with it. Out of their profits the company kept the plant in repair, but they allowed 5 per cent. in addition for depreciation. If they allowed 7½ per cent. it would take away half the dividend paid during the past year. £212 was spent in repairs during 1888, but that did not come out of the £3,100 additional capital raised. The £3,100 was mixed with the other monies, and drawn upon for repairs.

Mr. BOXALL: Then that is another £212 to come off your profit. The rest of your profit is entirely made up from wiring new premises.

The witness said that they made a profit of about £360 in wiring new premises. He had not calculated the mileage of streets in the area they proposed to supply, nor did he know the number of houses in the area. They had calculated that if they put down plant capable of supplying 12,000 lights they would be able to meet the demands made upon them during the first year, and they would be prepared to increase their plant as the demand increased. The witness admitted that he had been connected with one company that went into liquidation, and in a sub-company he lost £12,000, but said no supply company he had started had been unsuccessful. He named the Brighton Company and the Hastings Company as instances of successful companies. The Hastings Company was started at about the same time as the Brighton, and paid a dividend last year of 3 per cent. The Eastbourne Company had not paid any dividend, but it had been a very successful company. He had not calculated what the cost of converting twenty miles of overhead mains into underground mains would be. They proposed to appropriate £25,000 of capital, but they would call up their capital as demands came upon them. They had a distinct plan for a new station, but they had not bought the land for it, and he declined to mention the site they had in view. They would be willing to deposit £2,000. He would be willing to have a clause revoking the powers given by the order unless the whole of the capital was allocated and £50,000 subscribed within two years. He should not be willing to limit the area. He was willing to meet the Corporation as to the length of notices.

Cross-examined by Mr. HOWLETT, the witness said he was not aware that there had been great difficulty occasioned to the Gas Company at Eastbourne by the Electric Light Company's work, and he was not aware of any complaints being made by the Gas Company. He had never heard of anything spoken of in the following paragraph:—"There is scarcely a day that the electric light people are not at work in some part of the town repairing their cables, and in many instances their mains have been run in the soft ground of the Gas Company's mains, and in some places between the Gas Company's mains and the kerbs, so that it is very awkward for the Gas Company's men to drill their gas mains for new service pipes." It was their intention to lay mains in every street in Brighton and Hove if the electric light was demanded.

Re-examined, the witness said that the company had not chosen the persons whom they had supplied, but had supplied everyone who had applied to them.

Mr. ARTHUR WRIGHT was next called, and, in answer to Mr. WILLS, said he was an engineer of the company and had been connected with it since 1881. From his experience of electric lighting he was of opinion that the electric light in Brighton and Hove was not in an experimental state, but that it was in a practical commercial stage. The system which had been supplied had been practically convenient for the town. They had tried three systems, and he agreed with Mr. Hammond that the company were not tied to any system. The company's plant had been duplicated lately in order to provide against any breakdown. He understood the Hove Commissioners thought electric lighting not sufficiently advanced to be supplied. He considered that Brighton was well suited for the accommodation of electric light; in fact, with the exception of London, better than any town in England. There was no difficulty in supplying it underground, nor in relation to metering the electrical currents. In his estimation the price proposed by the company was not exorbitant; in fact, it was too reasonable. At any rate, it was not hard on the consumer.

Cross-examined by Mr. BOXALL: They had received complaints. The system now in force had been adopted since last July.

Cross-examined by Mr. WALLACE: With overhead wires it was very difficult to distribute electricity. During the year 1888 14,910 units were supplied.

Re-examined by Mr. WILLS: The present sliding scale came into operation on January 1st, and it was, he believed, a non-paying concern on the present basis. That was done to encourage consumption. There was no doubt that in making a larger supply they could do it more economically.

Mr. WILLIAM LOWRIE, engineer of the company at Kensington, said he understood he was to be constructing engineer to the Brighton Company should they get the powers they desired. He was the engineer to Messrs. Hammond and Co., and had charge of the construction of new works at Eastbourne. He had nothing to do with the management. The contract at Eastbourne had been carried out to the satisfaction of the Corporation. He understood that it was intended to substitute underground mains for overhead, and he saw no difficulty in carrying it out. The cost of the change must depend upon the district. For a thousand lights per mile he should say that the cost would be about £400 per mile for conduits. He should think that the company would find it to its interest to adopt the underground mains.

Cross-examined by Mr. BOXALL, the witness said he was consulting engineer to the Eastbourne Company. The mains and service pipes at Eastbourne were all underground. They were put underground without the assistance of a Provisional Order. The mains were also underground at Hastings, having been put under without the assistance of a Provisional Order. At West Brompton they supplied about 500 lights. The cost of the mains and laying them would average about £800 a mile. No difficulty was experienced in finding places to put their mains in the streets at Hastings and Eastbourne.

Cross-examined by Mr. WALLACE, the witness stated that the cost of producing electricity at Brompton under the system in existence at Brighton was 3½d. to 4d. per unit. Under the pavements he would not require to go to a greater depth than six inches in laying mains.

Cross-examined by Mr. HOWLETT, the witness said that it was not true that scarcely a day passed that the electric light people at Eastbourne were not at work in some part of the town repairing their cables. It was true, however, that they had a fair amount of repairs to do at Eastbourne. The first cables were put down at a time when little was known of electric lighting and were very faulty. The cables put down under the alternating system had not been repaired.

Re-examined: They had power at Kensington to supply 6,000 lights, although at present they only supplied 500.

Major-General KENYON STOWE, 31, Brunswick-terrace, Hove, said he had had an installation in his house from the Brighton Company for about a year. There were nineteen lights. He had no complaints to make except with regard to a slight bobbing up and down when they turned out the Alhambra lights. He would not be without it under any consideration.

Cross-examined by Mr. WALLACE: He did not care from whom he got the light as long as he got it.

Mr. LUNDY, manager of the Brighton Alhambra, said that they had about 300 lamps, which were supplied by the Brighton Electric Light Company. The lamps gave a splendid light, and it was of great advantage to them. He had seen the electric light at the Empire and Pavilion in London, near the Grosvenor Gallery, and elsewhere, and the Brighton light was the best he had seen at a place of public entertainment. He thought it would be a public advantage for the company to obtain the powers they sought and supply the town.

Cross-examined by Mr. BOXALL: He could not say that the directors of the Alhambra were intending to discontinue with the Brighton Company and obtain their light from London. If that were so he thought it would be on account of cost rather than the quality of the light.

Mr. PEAKE, 16, Belgrave-place, Kemp Town, said he had seven lights supplied by the Brighton Company, and he found it excellent in every way. The previous night, thinking he was coming to the inquiry, he put himself in the main circuit, and there were no ill effects whatever.

Prof. GEORGE FORBES said he was of opinion that the electric light was not by any means in an experimental stage. It was admirably adapted for house-to-house lighting. He did not think the company would have any difficulty in insulating 2,000 volts, or that any difficulty would arise in continuity of lighting.

Cross-examined by Mr. WALLACE: There was really little work done in England in regard to the system proposed to be adopted in Brighton by the company. He knew it was very largely adopted in some other countries. In his opinion the number of central stations on the alternating-system exceeded those on the direct plan. He would not speak positively that such was the case. He considered Hove was not suited for a battery station.

Mr. GEORGE HECKBURN, manager of the Bedford Hotel, Brighton, stated that the hotel had an installation from the company, and he found it had worked very satisfactorily, and the customers liked it. During the last two months he had made a calculation and found it came to a 1¼d. per light per night.

Mr. ALFRED ROGERS, an estate agent, said that since Monday afternoon last 2,996 signatures had been obtained from all classes of society in Brighton and Hove in favour of the electric light, and a petition had been prepared to the effect that the electric light would be most welcome, and hoping that the Provisional Order would be obtained by the Brighton and Hove Electric Light Company in order to do away with the objectionable practice of having overhead wires.

At this point the inquiry was adjourned.

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FRIDAY, APRIL 12.

On the resumption of the inquiry, ROBERT REED was first called, and said he went round with a petition in Over-street, Brighton, for the purpose of canvassing.

Mr. WILLS, Q.C., intimated that he had 1,900 other signatures that morning.

This closed the case on behalf of the company.

Mr. BOXALL then addressed Major Marindin on behalf of the Brighton Corporation, and stated that the company came forward asking for a Provisional Order to supply an area where the local authority withheld its consent, and when such an authority was itself armed with an order to supply the district or a part of it if they thought it desirable. Mr. Boxall characterised it as a remarkable application that they desired to supply a very wide area with a very small capital. They had come before them without any figures and without any calculations indicating what the expenses of supply to the area which had been named would be and what the requirements of the area actually were. They did not disclose any prospect of financial success, they did not attempt to show—and he submitted if they had they had absolutely failed—that it could be a paying concern and as to whether it would be likely to return a dividend. They came there but did not inform them that they had made any attempt to obtain the leave of the Corporation for laying mains underground, as it was alleged they had succeeded in doing at Eastbourne and Hastings. On the contrary, what they had done there had been to put down—as they had informed them—over twenty miles of overhead mains. They had got before them the report of the Government inspector showing that those overhead mains were not properly insulated and were insecure and unsafe. He did not see why they should accord them exceptional assistance by means of that order, entitling them for 42 years to have what was practically a monopoly supply of electric lighting in the town, which would authorise at least three years wherewith to maintain the present unsafe system of overhead mains and give them the power of breaking up and interfering with the streets and roads, which were vested in the local authority whom he represented and whom his friend (Mr. Wallace) represented. All these rights they were to have because they had already raised up in position unsafe overhead wires. He submitted that if that were taken as a reason and they were to have those advantages it would be a most unfortunate precedent; and with no other inquiries which were likely to take place it would be open for the persons promoting the company to get very large subscriptions from the public, knowing how easily they (the public) were attracted to anything in the shape of statutory authority. It would be a temptation to such undertakers to commence with a very small system and a very small capital in the various towns and in defiance of the local authorities by commencing overhead mains, and then they would go to the Board of Trade to get power to break up the streets and roads. The Brighton Electric Lighting Company started under exceptionally favourable circumstances, obtaining their premises, plant, and works at an enormous discount on the original cost, having the able management of Mr. Hammond as chairman and Mr. Wright as manager, and yet they were only able in the third year to show a dividend of 5 per cent. But when they came to analyse the balance-sheet they found that only 5 per cent. had been allowed for depreciation, and that a profit of £532 included £357 from wiring new premises, which could not be expected to continue. Mr. Boxall submitted that 7½d. per cent. at least should be allowed for depreciation, and if they allowed that and the £357 were deducted from the profit, instead of a profit the balance-sheet would show a deficit of £100. This deficit was made under favourable circumstances, when higher prices were being charged than the maximum prices authorised by the draft Provisional Order, and the manager had himself told them that with the prices now charged the electricity must be supplied at a loss. What prospect was there then of the company being successful? Then on Mr. Lowrie's estimate the cost of placing the twenty miles of overhead wires underground would be £16,000. How could they expect to pay a dividend? This was a matter of great importance to the Corporation, and they had a right to ask, "Is this going to be a permanent supply to Brighton, or is it only going to be a sale of a valuable concession to a number of shareholders upon an increased capital and then a liquidation, or a user for the term of three years of the overhead wires without any honest attempt to replace them by underground mains—a profitable user during that time and then a break up, perhaps, of the company?" For he submitted that for three years neither the Corporation nor any inhabitant of the borough could require the company to lay a main, and therefore, unless the company was to be permanent the powers they took were all to their advantage. The Corporation had themselves power to supply electricity, and intended to do so when they thought the time had arrived when they could do so with advantage to the community. He also called attention to the large number of pipes already under the streets, the narrowness of the streets, and the great inconvenience that would be caused by the company having the power to break up the roads, and, putting the objections briefly, said that the Corporation opposed the granting of the order not only because they thought the company financially insecure and because in detail its scheme was unworkable, but because it would have a right to interfere with their property.

Mr. LOCKWOOD, late borough surveyor and now consulting engineer to the Brighton Corporation, was examined by Mr. BOXALL, and said that in 1883 a Provisional Order was obtained, and in that year the Town Council caused a permanent installation of 500 lights, at a cost of £2,700, to be placed in the Royal Pavilion. In the following year, 1884, a further installation of 400 lights was added, which extended to the public buildings, such as the Assembly Room, the Free Library, &c., making the total installation 900, the total cost of which was £5,045. In 1887 it was found that the insulation of the installation was imperfect, and under the direction of Mr. Preece—who was that day unable to be present through indisposition—the mains were relaid at a further cost of £500. It was now in working order. The Brighton Corporation had a very good place a mile away for placing a station in case of the electric light being adopted. It was near the waterworks.

Cross-examined by Mr. WILLS: He could not say how long the Brighton Corporation would be before adopting the electric light. He was of opinion it was very much better that the powers of electricity should be in the hands of the local authority.

The Hon. REGINALD BROUGHAM (examined by Mr. BOXALL) said that he was electrical adviser to the Corporation. His experience with regard to the laying of mains for the electric light was confined to London; but they laid down a main through Chelsea about six weeks ago. The street in which they laid it was a very open street—such a street as Mr. Lockwood would call a clear run—and there were a great many reasons for getting the work done as quickly as possible, but though he had 160 men on they were ten days in doing 1,200 yards. He had no experience with regard to the cost of laying the mains except in London, and therefore he was prepared to take Mr. Lowrie's figures of £800 per mile for a thousand lights. He should say, however, that Mr. Lowrie had erred on the side of economy rather than extravagance. For the proper supplying of a place they generally calculated one light per head of the population. Perhaps 100,000 lights would be sufficient for Brighton exclusive of Hove. They could not possibly, he thought, put down the plant under a cost of £2 per light. That was for the installation buildings, &c. It did not include mains. For 100,000 lights this would come to £200,000. Then there were the mains. There were 72 miles of street in the borough, and though a main was not required in every street, mains carrying more than a thousand lights were necessary in some streets, so that it would be fair to estimate 50 miles of mains. Fifty miles at Mr. Lowrie's estimate of £800 per mile would come to £40,000. Thus the plant, &c., for properly supplying the whole of Brighton with the electric light would amount to £240,000. Such an installation would entail a large amount of coal, and it would be inconvenient to have the plant in the town itself; it would be much better to have it outside the area. In his opinion 5 per cent. was not sufficient to allow for depreciation of premises, plant, and circuit. The overhead wires would depreciate to the extent of from 10 to 12 per cent. Five per cent. was a sufficient amount on the engines, providing they were properly looked after, and 6 per cent. would be a fair amount to allow on the dynamo. He thought an allowance of 7½ per cent. all round would be about right.

Cross-examined by Mr. WILLS: He had been an engineer all his life. He was a director of the London Electric Light Company and of the Grosvenor Gallery Company. The Grosvenor Gallery Company was sold to a large company, but it had not paid a dividend.

Mr. WALLACE, in addressing the Inspector on behalf of the Hove Commissioners, said it was a rather peculiar district compared with other towns in that it was extremely regularly laid out and contained a very superior class of houses. The town of Hove was governed by Commissioners, a body of men who were well able to give their attention to the matter, and had a good deal of time on their hands. They had given considerable time and attention to the various systems of electric lighting, but up to the present time they did not feel altogether justified in adopting any particular system. They came before him to oppose the Provisional Order applied for by Mr. Hammond's company. The Hove Commissioners did not wish to criticise the efforts which had been made to obtain the order to supply electric light to Brighton, but they declined to give their consent on the ground that the time was not a right and proper one for the supply of electric light to the town of Hove, and when such was wanted the Commissioners were the proper persons to choose the best system, and they could, moreover, find the capital for it. They had appointed two of their Commissioners as a sub-committee to investigate the various systems, not only of the company of the promoters of that order but also other systems in various parts of England. The results of their investigations had been that there were other systems which were considered to be much better than that proposed by Mr. Hammond.

The witnesses were then called on behalf of the Hove Commissioners.

Mr. G. B. WOODRUFF, the Chairman of the Works Committee of the Hove Commissioners, said he was formerly for many years a civil and mechanical engineer. He was familiar with the requirements of Hove, having been six years a member of the Commission and three years Chairman of the Works Committee. Up to the present there had been very little demand for the electric light. There were only ten houses which had it laid on, but there might be a few more who wished to take it. Those who had it were not entirely satisfied with it on account of the flickering. He certainly thought that some form of storage was desirable. He knew of no machinery that could be relied upon. They found in all the works they visited that the machines sometimes broke down. Hove was purely a residential neighbourhood, and the noise of machinery at night would be very objectionable. He had made calculations as to the cost of various systems, and found that economy was to be found in some system of storage. The Hove Commissioners were not against electric lighting in itself, and they hoped in time to light the town themselves. In a few months they hoped to secure a good system. He considered that the company's system of putting street mains would be thoroughly bad for Hove. Their mains were large and cumbersome, and the Commissioners objected to their being laid under the carriage way. The Works Committee had in mind suitable sites for erecting works.

Cross-examined, WITNESS said that in his opinion the town of Hove ought to have a Provisional Order or license to do the work themselves Having that order, it was open to them to contract with any good company they chose. The Commissioners would not desire to have several companies operating at one time in the town, and he objected to two companies competing to supply the town. The Hove Commissioners, he thought, would be able to supply the light cheaper than the company, because there was the Town Hall and public streets which they could supply, and there were systems which could supply electricity at a much

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cheaper rate than the system of the Brighton company. Since January 24, when the report was adopted by the Commissioners, witness had obtained information with regard to the different systems of electric lighting from Mr. Henry Edmunds, Mr. Sayers of Chelsea, Mr. Crompton, Mr. King (the electrical engineer to the Electric Power Storage Company), and he thought he might add Mr. Wright and Mr. Lowrie, though he could not say whether he had seen Mr. Lowrie since January 24. He had made up his mind that some form of storage was the system for Hove. The Commissioners had not passed a formal resolution in favour of the Brush system.

Re-examined, WITNESS said that he read all the scientific works and reports of engineers on the subject as they appeared.

In answer to the Inspector, the WITNESS said he could not say definitely that the Commissioners were going for a Provisional Order, because they had not passed a resolution to that effect, but knowing the feeling of the Commissioners generally he believed they would apply for one.

Mr. H. H. SCOTT, Borough Surveyor at Hove, examined by Mr. WALLACE, said there would be difficulties to be overcome in laying down the mains under the pavements, in consequence of cellars and other matters.

Mr. R. E. CROMPTON, Managing Director of "Crompton and Co.," spoke of his experience with regard to the carrying out of large central stations both in England and on the Continent. He had examined the station of the company at Brighton, and considered that under that system there were no known means in this country for supplying motive power.

Cross-examined: He was an advocate for the battery system. He made the plant for both systems. He made converters for towns in South Africa and Australia. He should think the accumulator system preferable for Brighton. He was not aware that Viscount Torrington, the chairman of his company, had written to the Corporation asking to be allowed to light the town with electricity, though he knew he was exerting himself in Brighton. He should advise several subsidiary stations for Hove, charged as in the cases of Darmstadt and Vienna. The Brighton Electric Company might apply the battery system, but a large portion of the original capital would have to be spent in distribution on the original system. By that he meant that the mains in the streets would not be useful in the battery system because the section of copper utilised would be too small.

Mr. J. W. HOWLETT, who appeared on behalf of the Brighton and Hove Gas Company, stated that they had objections to Clauses 11 and 12.

The INSPECTOR suggested that any alterations which it might be deemed advisable to make by the Brighton and Hove Gas Company might be made in writing and directed to him and be presented to the Board of Trade as amended.

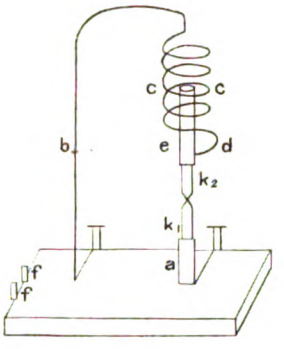
With this Mr. HOWLETT acquiesced.

Mr. WILLS, replying on behalf of the company, contended that the petitions which had been handed in were of some substantial value. They had not so much to consider whether they were the very best company in the world, or whether the Brighton Corporation was the worst, but simply to judge as to whether the interests of the community would be enhanced. He pointed out the special circumstances of the case before them, and alleged that although the Brighton Corporation had had a Provisional Order for supplying electricity since 1883, yet not a step of any importance had been taken. It had been a "dead letter" to the present day. He contended that the company whom he represented had been giving satisfaction to their customers, and he had no doubt they would continue to do so with increased powers given them. Notwithstanding the very able and exhaustive speech of Mr. Boxall, he never put a single member of the Corporation into the box to say that the company was not to be trusted, or ought not to have the Order they asked for. The Town Clerk had been present throughout the inquiry, but had not been brought forward to say that it was not in the interest of the Corporation that the powers should be granted to the company, or that there were complaints against the company. Proceeding to consider the grounds of opposition, Mr. Wills said he quite acknowledged the propriety of the Corporation using all fair efforts to see that they were not prejudiced, and to require to be satisfied on matters of finance, but he adhered to his offer to make a deposit of £2,000, and to subscribe such capital as the Board of Trade should require. That would give security to the community, and give the company a great interest to do the work efficiently, cheaply, and well. As to site, any new station should be subject to the approval of the Board of Trade. He would agree that the prices should not be increased after seven years, and as to the company's prices prejudicing those of the Corporation, the Corporation could easily go to the Board of Trade and get another Provisional Order so as to raise their charges. But the great objection, both of the Corporation and the Commissioners, seemed to be that house-to-house electric lighting was still in an experimental stage. He had called eminent witnesses, however, to disprove that, and even Mr. Brougham, one of the witnesses for the Corporation, admitted that for two years it had been beyond the experimental stage. As to the Commissioners, Mr. Woodruff could not say that they would go for an order; and suppose they did, what guarantee was there that they would use it, or that the ratepayers would allow them to spend the requisite money on plant. Surely it was far better to let the company run the risk, which they were willing to run, and to supply the place. With regard to the system, Mr. Wills submitted that he had called evidence to show that the transformer was the best, but the order tied the company down to no system. If the order were granted the company would bind themselves to proceed with all reasonable despatch in replacing the overhead wires with underground to the satisfaction of the Board of Trade, and would agree that the deposit should not be released until the work was done, or that if within a year after the order a third of the work was not done a third of the deposit should be forfeited; or they were willing that the three years should be reduced in any way the Board of Trade might think fit. As to Mr. Howlett, he was afraid all he could say in the way of consolation to him was that they would give him every protection the Board of Trade allowed to other gas companies elsewhere.

At the conclusion of Mr. Wills's remarks the inquiry terminated.

AN ARC LAMP FOR AMATEURS.

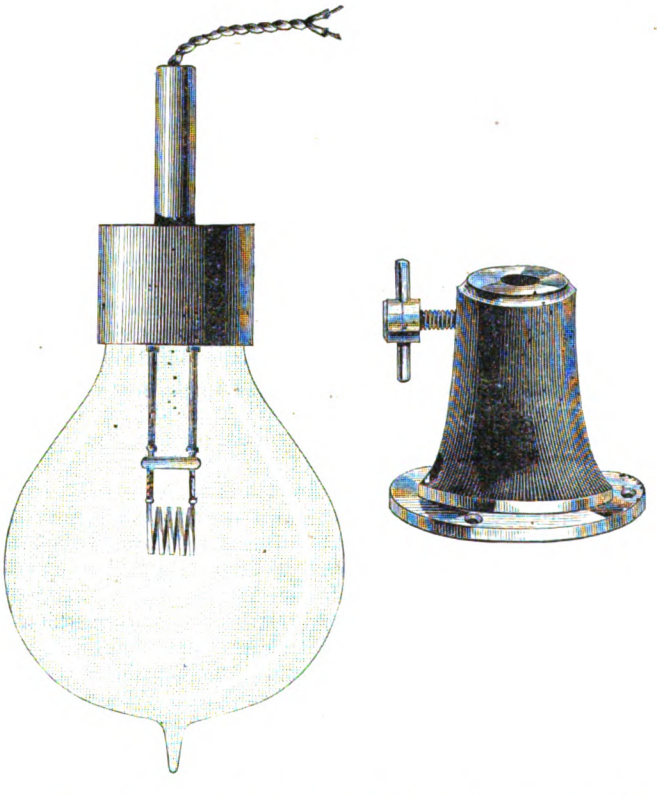
In a recent number of the *Zeitschrift für Elektrotechnick* Dr. Gerlach describes a cheap form of arc lamp made by M. Jordan, of Parchim, which he has been in the habit of using for several years for demonstration purposes. Into a wooden pedestal is screwed the metal socket a, holding the carbon k_1 and a metal support b, which is in electrical connection with one end of the coil c. The other end of the coil c is connected by a flexible wire, d, to the upper carbon k_2, through the iron holder e, which is capable of moving freely within the coil. When the current is passed through the lamp the iron-holder is sucked in and the arc is struck, and according as the current decreases and increases the upper carbon



is lowered and raised, the lamp thus proving self-regulating. If the current is strong enough to lift h, but is unable to maintain the arc, the small cylinders $f f$ can be attached to the carbon holder, which, by adding to its weight, diminishes the length of the arc.

AN INCANDESCENT LAMP FOR OPTICAL PURPOSES.

It is well known that if an ordinary incandescence lamp having a horse-shoe or looped filament is placed in the principal focus of a lens, the lens will gather into a parallel beam of light only a very



small portion of the whole light given out by the filament. In optical work a light is required which is emitted from a small luminous area capable of being almost wholly placed in the focus of a lens or reflector. Apart from their intrinsic brilliancy it is this compactness which renders the arc light and the limelight so effective as sources of light in optical apparatus. To meet this desideratum the Edison-Swan Electric Light Company have recently brought

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out an incandescence lamp of a particular pattern in which a suggestion by Dr. Fleming has been practically worked out by Mr. Gimingham with the result of producing a glow lamp admirably adapted for these purposes.

The sketch shows the arrangement. In a nearly spherical bulb is fixed a carbon filament coiled into a flat spiral, the whole width and length of which is contained in an area of about one square centimetre. When the lamp is incandescent this flat spiral appears as an intensely luminous and compact focus of light, and when the lamp is placed in the focus of a lens and suitable mirror, nearly the whole of the emitted light can be condensed into an approximately parallel beam. A lamp of this kind, of 60-70 candle-power, is very well adapted for use in the optical lantern. We are informed that Dr. Fleming has had them in use now for a sufficient time in lantern work at University College to be satisfied with their performance. They can also be used with advantage in ship's side-light lanterns, and in small projectors. As the distribution of electric current extends in private houses it will be doubtless found that a simple form of optical lantern employing such an incandescent lamp is the most convenient and pleasing mode of exhibiting photographic slides and transparencies.

For lecture-room work, where current is available, it will afford a means of showing lantern views with less trouble than limelight or mineral oil lamps, and for use as a source of light which is, in some respects, more tractable than the limelight even though less intense, this form of glow lamp will have its uses. A suitable holder and stand has been designed for the lamp, which has been called the Ediswan Focus Lamp.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 6, 1889.

In one of my recent letters I called attention to some interesting figures showing how largely the gas companies in this country were now devoting their attention to the introduction of the electric light. It is a little bit amusing and singular to see that the old competition and hostility which is thus disappearing above ground should be renewed underground, and should be occupying very largely the attention of gas and electrical engineers. In other words, now that we are having electrical subways laid in most of our large cities the most important question that has arisen in connection with them is how to keep them free from gas. So far, no means have been found to prevent gas escaping from the pipes, and hence every now and then we have some bad explosions. There have been explosions in Philadelphia and other cities of serious proportions, and latterly New York has been startled by similar unpleasant experiences. Last week I mentioned the explosions near the Fifth Avenue Hotel up town,* which made a very deep impression on the public mind, and have now led to a special investigation of the matter by the Board of Electrical Control. The Board has had before it this week a number of representative men connected with the gas companies and the steam-heating companies, and has endeavoured to ascertain from them whether it would not be possible to prevent the leakage from gas-pipes. As far as it has gone it has discovered that there is considerable difference of opinion on this subject. Some of the gas engineers admit a direct loss of 5 per cent. by leakage, and appear to take it for granted that that is normal and reasonable, while others went so far as to intimate that it was unavoidable and was practically allowed for in the scheme of creation. Mr. Jackson, of the Westinghouse Company, a gentleman who has had great experience in connection with natural gas engineering in Pittsburg, said that in that city they had eliminated leakage from their calculations by careful work, and that the loss by that cause did not amount to one-half of 1 per cent. Admitting, however, that the gas-pipes in New York would leak, and that the gas escaping would find its way into the conduits, the Board had further to ascertain whether there was not some remedy for the explosions, and upon this second point a number of opinions were ventured. President Andrews, of the New York Steam-heating Company and of the Standard Gas Company, suggested that the ventilation of the manholes was the proper means, the covers being perforated; but Mr. Beckwith, the engineer of the Board, opposed this, saying that the gas escaping through the perforations of the covers would be more than ever likely to be ignited by stray matches. It was finally decided to make an experiment in ventilation by running small pipes through the manholes to the tops of the electric light poles, but there are doubts in some quarters as to the efficiency of this method. One of the technical papers here, the *Engineering and Mining Journal*, the editor of which is Mr. R. W. Raymond, who is one of the Subway Commissioners for Brooklyn, suggests that, in order to prevent the manhole lids from flying about in a loose and casual way, it would be a good precaution to fix them on one side with hinges, so that when the explosion did take place the cover would simply flap open like a door. It is obvious that this is a practical remedy, for the startled passer-by, as soon as he has recovered his equanimity after the explosion, can shut down the lid again, and a minute later nobody would be anything the wiser as to the occurrence of the explosion. The only trouble with regard to this remedy is that so far the explosions have not merely hoisted the covers in the air but the best part of the manhole too.

The rapid extension of electric railways in this country has, I notice, more than once called forth surprise and admiration in England, but I doubt whether the full scope of the revolution in urban passenger traffic is yet comprehended abroad. Figures and facts are always better than vague and general statements, and I am glad to be able to refer in this respect to some statistics which have recently been compiled by the *Street Railway Journal*. The results brought out exceed the most sanguine and most enthusiastic anticipations of electrical engineers. In a paragraph above I have alluded to the change of front with regard to electricity on the part of the gas companies, and I think that the street railway companies are even more appreciative of the benefits that the practical applications of the new force can confer on them. The *Street Railway Journal* reports having gathered the following data from several hundred replies to circulars which it distributed among the street railways of the country:—18 per cent. did not contemplate making any change from horses, and of this number one-fourth expressed themselves as satisfied with horses or unable to change because of the terms of their franchise; 15½ per cent. did not answer the questions at all; 16 per cent. were awaiting developments, desiring to change to mechanical traction whenever they could find a practical system, but preferring no particular method; 16½ per cent. favoured methods other than electricity, such as cable, gas motors and steam motors; 34 per cent. have either decided on electricity in some form or contemplate so doing, and of this number one-third prefer the overhead system and about one-ninth favour storage batteries. Thus out of the entire number of replies 66½ per cent. may be said to be so thoroughly dissatisfied with horses that they have already abandoned them or are watching for an opportunity of doing it; and if to that number we add the 15½ per cent. who did not answer the questions we might say that 75 per cent. of the street railways of the country have declared their sentiments against horses and in favour of mechanical traction. It will be noted that of the 66½ per cent. more than one-half favour electricity, and if we take into consideration the new roads being projected or built we shall find the proportion for electricity is even larger. It is evidently much easier to start out with electricity on a new road than to apply it to an old road already equipped with horses, stables and the old-fashioned rolling stock. I think it will be conceded by your readers that this is a remarkable exemplification of rapid electrical development.

As compared with England, this country has seen very little special building of dynamos for marine work. In the absence of a large mercantile marine and of an extensive navy, the opportunity has not presented itself to marine dynamo builders of much work in this direction; but latterly, with the greater activity in the establishment of what is known as the "New Navy," there have been some good chances, and the result is that one or two new and interesting special types of machines have been brought out. Just now it may be said that the Edison Company is practically monopolising the new naval

* This paragraph was held over last week for want of space; it will now be found in our Note columns.—ED. *E.*

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work, and it has recently brought out for the cruiser "Yorktown" a new multipolar compound wound machine, with a Gramme ring armature, designed to give 100 amperes at 80 volts. This machine is a radical departure from the familiar Edison type, and the idea is, of course, to economise in space, material, &c. There are eight poles, four external to the armature and four internal, the latter being placed not opposite the external poles but in each case midway between them, so that any one section of the armature passes alternately over the internal pole and under the external. The field is generated by a circular coil in the shape of a field ring, which is inserted vertically between the two sets of poles occupying the space between the keeper and the armature, and also between the two sets of poles over the internal and inside the exterior. This field magnet consists of both series and shunt windings, and is kept in position by small projecting lugs on the pole pieces. The ends of each section of wire on the armature are soldered into the adjacent cups of the commutator bar, and after this connection is completed each cup is connected by a wire with the three cups at right angles to it and to each other. By this means only one set of brushes is required. The commutator has 144 bars, and the brushes are set at points on the circumference of the commutator, making an angle of about 135 degrees with each other. The switchboard is placed on the top of the dynamo. The machine is coupled direct with a special Armington and Sims engine. The connecting coupling between dynamo and engine-shaft is a flexible one, the connecting medium being a disc of leather. The weight of the dynamo, including the bed-plate, is about 2,000lb., giving 4 watts to the pound, and the larger machines of 200 amperes now being built for new cruisers give 5 watts to the pound. Allowing the normal heating area, as employed on the special machines built in Europe for this purpose, they give 12 watts per pound. The machines are provided with the new Edison pattern of self-oiling bearings, which have a reservoir of oil in the surrounding shell and require no oil cups. It may be mentioned that the specifications made by Lieut.-Commander Bradford required a temperature of the dynamo, after a test of one week's continuous run, not exceeding 40° Fahrenheit above the surrounding atmosphere on either the armature or the field magnet, with the additional condition that the maximum speed should not exceed 400 revolutions per minute.

The annual report issued last week by the American Bell Telephone Company shows that company to be in a highly prosperous state. The earnings will allow it to pay dividends on its total capital stock of 24 per cent., but the stockholders have to be satisfied with an insignificant 18, the sum of $600,000 being transferred from the net surplus of the year to a reserve account, the directors believing, with wisdom perhaps, that a part of the income from royalties should be treated as capital. It is interesting to note that the payment to the Western Union Company under the old contract for sitting still and doing nothing amounts during the past year to $467,000. It is probably as handsome a premium as was ever paid for indulgence in *dolce far niente*. The far-sighted policy which animates the management of the American Bell Telephone Company is seen not only in the transfer of the $600,000 to the reserve fund, but in its provision for a magnificent new telephone building in Boston, and in the fact that the investment in long-distance telephone lines now amounts to about £450,000, the greater part of this money having been obtained by the issue of 7 per cent. debenture bonds of the company for $2,000,000, which were offered to the stockholders at par and subscribed for by them. The business of the long-distance lines has been good, and is increasing, the service rendered being excellent; in fact, I think it may be characterised altogether as the best electrical service now being given in America. The business would be much better but for the fact that the larger cities still wait for the establishment of a metallic circuit system for their local lines. The company now has in the hands of licensees under rental no fewer than 411,511 instruments, being an increase for the year of 31,234. The subscribers in the various exchanges through the country make an average of 6·13 calls per day, and of these subscribers there are 171,000 concentrated in 742 exchanges and 452 branch offices, on 170,000 miles of wire, and served by 6,310 employés.

BERLIN NOTES.

(FROM OUR CORRESPONDENT.)

BERLIN, *April* 8, 1889.

On April 6 the ordinary general meeting of the well-known electric light company of Berlin, the Allgemeine Elektricitäts-Gesellschaft, was held. I therefore take the present opportunity to call attention to the development of this company and to give you a short account of the progress in electric transmission of power from the Berlin central stations. The chief resolution come to at the meeting was that the capital of 12,000,000 marks should be increased to 16,000,000 marks. The directors of the company justified their demand for an increase of capital by the extensions of the foreign business of the company, and especially in connection with several central stations. Indeed, the increase of capital is fully justified by the growth of the manufacturing business of the company, which during the past year was more than doubled. Moreover, no trifling portion of the capital has been expended in acquiring the German licenses of all the patents of the Electrical Power Storage Company and in establishing the manufacture of this branch of electrical engineering.

The manufacture of electric motors in Germany already forms a considerable part of the electrical engineering industry. Almost all electricians of any importance have designed new types of electric motors, the sizes of which vary from $\frac{1}{12}$ horse-power for sewing machines and other machines requiring little power up to 10 horse-power. All German engineers agree in the opinion that high efficiency should be the main point in designing electric motors, even if the number of revolutions or the prime cost come out very high. Though in Berlin the electric motor is not as yet generally used, nevertheless there are already a great many industrial power users to be found who avail themselves of electricity. Up to the present the motors have been most prudently employed to drive fans and ventilating apparatus; now, however, a great many shopkeepers and tradesmen have begun to recognise the advantages of the motors. Among the industrial consumers there are also shopkeepers who drive their sewing and cutting machines and their coffee and pepper mills by electricity, as well as printing offices and owners of pumps and lifts. For instance, in the lithographic printing office of Herr Winkelmann there are five electric motors, two 1 horse-power and three of $\frac{1}{2}$ horse-power. Each lithographic press has its separate motor of $\frac{1}{2}$ horse-power, and each machine for polishing the lithographic stones and plates has its motor of 1 horse-power, while the fifth motor of 1 horse-power drives three printing presses of various types and sizes through shafting. Notwithstanding the comparatively high cost of electric current in Berlin the working expenses do not greatly exceed those of gas engines. The electric motors of the Allgemeine Electricitäts-Gesellschaft are self-regulating, and have a very high efficiency; on account of the so-called ring lubrication of their bearings they need no oil supply more than once a month. In some cases the saving made by using electricity in lieu of other power may be very considerable; for instance, Herr V. Maulheimer, who has in his well-known establishment a lift which was driven till lately by hydraulic power, water being obtained from the town mains, has now established a pump driven by an electric motor, which pumps the waste water into a reservoir at a height of 25 metres. Since this alteration the working expenses of the lift are reduced by more than 25 per cent.

CORRESPONDENCE.

PROF. OSTWALD'S EXPERIMENT IN ELECTROLYTIC DISSOCIATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I wish to emphasise the criticism of Mr. J. Brown (p. 676) concerning what Prof. Ostwald has published regarding dissociation and electrolysis, and I regret to say it seems to be necessary to take rather serious ground. I trust that this seeming is owing to some misapprehension of mine, but I have delayed writing on the matter for six months or more in the hope of having it removed.

There has for long been some uncertainty and debate as to how the free, or potentially free, atoms, postulated by Clausius to explain electrolysis, were to be conceived; whether free charged atoms could really dance through the liquid, remaining dissociated for some time, or whether the postulate involved merely a slight modification of Grotthus' original hypothesis and signified only a directed molecular interchange of a very easy and unresisting kind.

I understand Prof. Ostwald to have espoused the former view, and to adduce in its support an experiment of a remarkable

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character, the description of which is translated by Prof. Ramsay in *The Electrician* of March 1 as follows:—"Two glass vessels, insulated, each contain a solution of potassium chloride. They are connected together by a siphon filled with a similar solution of potassium chloride. A negatively electrified rod is placed near one of the vessels, and while it is still there the siphon is removed. The vessel nearest the rod is now positively electrified; it has received a positive charge from its neighbour vessel, and this charge has carried with it positively electrified potassium atoms, while negatively electrified chlorine atoms remain in the other vessel. These atoms are *free* in the solution. When a conducting wire is now dipped into the solution, the potassium atoms float up to it, part with their positive charges, and then act on the water, forming potash and evolving hydrogen, which, if the charge was great enough, appears in bubbles, but which at all events polarises the platinum wire. Such an experiment shows that it is easy to prepare a liquid containing excess of one or other ion, and to separate the ion at the surface of an electrode by removing the electric charge of the ion."

I have seen the original Paper, and the above appears to me a fair representation of what it says.

Now among the mass of publication and scientific literature in which we are imbedded, if there is one thing more than another directly incumbent upon persons in authority, as a matter of simple morality, it is this: that all experiments recorded by them should be as absolutely trustworthy as they can be made, so that a person reading the description may be able to rely on the statements of fact as accurate, however he may please to differ from the views and interpretations put upon those facts.

Concerning this experiment, however, I was incredulous in spite of myself, and in spite of the high position of its author. Nevertheless, as in duty bound before saying anything about it in public, I proceeded to try it, although at every step the absurdity of the proceeding forced itself upon me. I connected two insulated vessels of KCl by a siphon; I brought near one a stick of rubbed ebonite, then removed the siphon, and immersed a platinum wire in each of the solutions. I have now to record that I saw no "potassium atoms floating up to the wire and parting with their positive charges," that I could detect no "formation of potash," see no "bubbles of hydrogen," nor could I be sure of the least trace of polarisation.

Now if it is merely my bad experimenting which accounts for these negative results, I shall be very ready to apologise. But in the light of my trial, and of such experience of electrical and chemical matters as I have been able to accumulate, I feel bound to say deliberately that I do not believe the experiment as described is a feasible one, and I do not believe the results described were ever witnessed.—Yours, &c.,

Grasmere, 10th April, 1889. OLIVER J. LODGE.

THE BERLIN CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think it would be interesting and important to know the section and approximate daily current curve of the Berlin cables, as it might turn out that at the time of full load they are heavily worked, and that in consequence there is considerable rise of temperature, which would accelerate deteriorating actions. Perhaps Prof. Forbes could furnish us with the necessary information to make this calculation?

One is reminded of the rapid deterioration of lead wire fuses, but this may be caused by the alternate heating and cooling cracking and detaching the superficial film of oxide which would otherwise protect the bulk of metal. Perhaps this action, combined with increased chemical action due to elevation of temperature, may be to some extent the cause of the failure of the Berlin cables.

We have, however, the fact that composition pipes are largely employed for both gas and water, and are buried in the soil without much distinction as to nature of soil, so that it would appear that the cable manufacturers have only to ascertain the experience of gas and water companies in order to secure a cheap alloy which, under ordinary temperatures and temperature variations, has stood the test of experience. Probably hot water engineers have experience on the behaviour of "compo." piping under very similar conditions to those which would obtain with a heavily worked cable.—Yours, &c.,

Lisbon, April 7, 1889. W. B. SAYERS.

[Load diagrams of the Berlin stations were given in *The Electrician* of June 29, 1888, p. 244, but we have no information as to the current density in the cables.—ED. *E.*]

STORAGE BATTERY PATENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a leaderette in your last issue on the recent decision in the United States Courts on the above subject may give rise to erroneous impressions, I would wish to point out that, far from the decision being unfavourable to the Accumulator Company of America, who hold the E. P. S. group of patents, it will enable them at once to place under injunction all who employ the only practical and commercially useful system for the manufacture of storage batteries, viz., the mechanical application of active material to the plates.

It is well known that no secondary battery has been successfully constructed in which the active material is not mechanically applied in the form of a paste, paint, or cement, and the attempt of Mr. Brush to make batteries otherwise resulted, as is a matter of common knowledge, disastrously to himself and his sub-companies in America, the whole of the batteries having to be taken back.

I would point out that we have not to deal with Mr. Brush in this country, and that though the judgment stated there was no doubt Faure made the invention in August, 1878, yet he was precluded by the American law (because he is a foreigner) from claiming the invention earlier than the date of his French patent, which was October, 1880; whereas the evidence of Brush was directed to the years 1879 and 1880 as the years in which he made his so-called discoveries.

As regards the Swan patent, the judgment decides that the invention of Swan is a patentable invention, and it quotes the evidence of Sir William Thomson thereon; but it holds the Swan patent in America to be invalid, because a Prof. Eaton testified that he made something similar to Swan's invention in August, 1881, whereas Swan's patent for the United States only dated from January, 1882, and the plaintiffs had not put in proof the date of the English patent, which was May 24th, 1881.—Yours, &c.,

J. IRVING COURTENAY, Managing Director of the Electrical Power Storage Company (Limited).

London, April 17, 1889.

DURTNALL v. SHIPPEY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Our attention has been called to your report in last issue respecting the above matter, which, permit us to say, has no connection with our firm whatever; and from inquiries we have made, your correspondent appears to have misrepresented the case altogether, which has nothing to do with us. We must therefore request you to insert this letter in your next issue, as we cannot allow such an erroneous report to go uncontradicted.—Yours, &c., JOHN TADD, Secretary.

(Shippey Brothers, Limited.)

13 and 14, King-street, Cheapside, London, E.C.

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 20, 1889.

4,846. C. K. FALKENSTEIN, E. ROSSEAU, and C. K. FALKENSTEIN. London. Improvements in electric light fittings.

4,849. C. V. BOYS. London. Improvements in insulators.

4,871. H. A. SEEGALL. Berlin. Improvements in the electrolytic process of obtaining copper, zinc, and tin.

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4,875. M. IMMISCH. London. An improved system for electrical transmission of power for traction purposes by direct current.
4,883. F. G. HOWARD. London. Improved apparatus for showing whether an electrical switch or contact-maker is on or off.
4 889. J. CERPAUX. London. Improvements in the generation of power for electric lighting and its application to dwelling houses and buildings generally.

March 21, 1889.

4,901. R. E. B. CROMPTON. London. Improvements in means or apparatus for use in conveying electric currents for lighting or other uses.
4,954. H. F. PRICE. London. Improvements in electrical battery cases.
4,960. G. M. LAWRENCE. London. Improved means for administering electricity to and otherwise treating horses and other animals.

March 22, 1889.

4,998. G. BOWRON. London. Improvements in magneto-electric machines.
5,010. F. V. ANDERSON. London. Improvements in galvanometers.
5,014. C. J. V. DEPOELE. London. Improvements in switches and in suspenders for overhead conductors in electric railways. [Date applied for under Section 103 of the Patents' Act, 1883, 25th August, 1888, being date of application in the United States.]

March 23, 1889.

5,063. E. H. HUNGERBÜHLER and J. T. TODMAN. London. Improvements in instruments for the measurement of electric currents and electromotive force.
5,066. P. A. NEWTON. London. Improvements in sockets or holders for incandescent electric lamps (A. Swan, United States).
5,084. A. J. BOULT. London. Improvements in electric clocks with synchronizing mechanism (R. Pouchard, France).

March 25, 1889.

5,093. W. J. S. BARBER-STARKEY. Manchester. Improvements in electric batteries.
5,095. T. J. HASLAM, jun., of the firm of WM. R. BOX and CO. Dublin. Improvements in the form and manufacture of the frames, plates, and cells of storage or secondary batteries.
5,104. A. E. LEWIS. London. Improvements in apparatus for communicating by means of an electric current with railway trains when in motion.
5,107. E. M. H. ANDREOLI. Brixton. Improvements in electro-chlorinating auriferous ores.
5,111. D. LEVISON, C. M. DORMAN, and R. A. SMITH. Manchester. Alarms for announcing electrically the discharge of automatic fire-sprinklers.
5,116. T. PEASE. Liverpool. Improved electric storage battery or accumulator.
5,127. E. J. DAVIS. London. Electric razor.
5,131. A. J. GRAVIER. London. Improvements in transformers for alternating currents.

March 26, 1889.

5,140. S. W. BAYNES. Bradford. Improvements in the laying of underground conductors for the conveyance of electricity.
5,152. E. ATKINS. Birmingham. Improvements in electrical, gas, or other lamp-globe or shade-holder.
5,160. J. PIGG. Newcastle-on-Tyne. Improvements in or relating to terminal shackles for wires carrying electric currents.
5,176. E. A. SPERRY. London. Improvements in or connected with electrical installations.
5,209. M. H. KILGOUR. London. Improvements in electrical alternate current motors.

SPECIFICATIONS PUBLISHED.

1877.

*4,225. HOOKHAM. Electricity meters. (Price 1s. 1d.)
Second Edition.

1884.

9,982. ABEL (Zipernowsky and another). Electric currents. (Price 8d.)

1886.

2,783. JARMAN. Electro-motors. (Price 8d.)

1888.

1,103. LOWRIE and HALL. Electric lighting. (Price 6d.)
1,162. KENNEDY. Electric governors. (Price 8d.)
1,223. BERG. Reply telegraphs for engine rooms, &c. (Price 8d.)
1,343. NALDER and OTHERS. Measuring electricity. (Price 6d.)
1,611. DEWEY. Multiplex electric telegraphy. (Price 8d.)
3,672. EDMUNDS. Electric circuits. (Price 8d.)
3,968. DUNBAR. Electric arc lamps. (Price 8d.)
5,191. EDMUNDS. Storage batteries. (Price 6d.)
6,928. ANDERSEN and TAFE. Electric switches. (Price 8d.)
7,901. HORNE. Electro magnets. (Price 4d.)
17,222 PAGET. Electric arc lamps, &c. (Price 8d.)

1889.

362. LAKE (THOMSON). Working metals by electricity. (Price 8d.)
375. BERNSTEIN. Electric glow lamps. (Price 6d.)
746. LUGO. Secondary batteries. (Price 6d.)
1,401. DYER and Others. Generating electricity. (Price 6d.)
1,677. WHITTINGHAM. Electric switch. (Price 8d.)
1,892. BOULT (SERREL and Another). Electric motors, &c. (Price 8d.)
2,066. PAGET. Secondary batteries. (Price 6d.)
2,276. GUITTON (SAPPEY). Primary batteries. (Price 11d.)
2,748. BENNETT. Telephonic switching apparatus. (Price 8d.)
Amended Specification.

COMPANIES' MEETINGS & REPORTS.

The Oriental Telephone Company (Limited).

The ninth ordinary annual general meeting of this Company was held on the 16th inst. at the City Terminus Hotel, under the presidency of Mr. William Addison.

The SECRETARY (Mr. Alex. B. Chalmers) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, In moving the adoption of the report and balance-sheet I congratulate the shareholders upon the steady although comparatively slow improvement in the position of the Company. Each year we are doing better, although the progress is certainly not rapid. With regard to the balance-sheet, your Directors, after having well considered the matter, have thought it better to recommend the distribution of a smaller dividend than apparently on looking at the balance-sheet they might have done, and their reasons for such policy are—First: To protect the shareholders from the possibility of a call by forming a reserve fund sufficiently large to meet any emergency that the Company may have to face, such as destruction of poles, wires, etc., by storms or cyclones. This reserve fund your Directors intend to make a thoroughly real one and to invest it in such substantial securities as may be easily realisable should the money be required quickly. Secondly: To enable your Directors to have sufficient money in hand for the purpose of pushing and extending the business should opportunities occur of advantageously doing so without having to call on the shareholders for more money; this we consider most important. Thirdly: Your Directors have a great objection to see brought forward in the balance-sheet from year to year a large sum for preliminary expenses, so after careful thought they have resolved to wipe that item off the accounts. These are the main reasons your Directors have in recommending a 3 per cent. dividend when perhaps another ½ or 1 per cent. might have been paid. But there is still another reason, which is this—having in view the future prosperity and stability of the Company, they are anxious to maintain steady dividends. Now you are all aware that 75,000 fully paid £1 vendors' shares will rank for dividend as soon as 30 per cent. in dividends has been paid to the other shareholders, having 11s. paid on their £1 shares, and which constitute by far the larger proportion of shareholders, viz., 3 to 1 of the capital. Having that in view, we think it just to these shareholders that we should use the power our Articles of Association give us to raise such a reserve as we may consider necessary whether for the protection of the Company or for the equalisation of dividends. The Board have control over rather more than one-third of the whole vendors' shares, 26,000 out of 75,000, which should satisfy the meeting that the interests of all classes of shares have been considered. In India the progress of the subsidiary companies is slow, and it is certainly not helped by the policy of the Indian Telegraph Department, which seems to your Directors almost antagonistic. Until some amelioration in the relations of the Indian Companies and the Indian Telegraph Department has been effected, we shall continue to advise the utmost economy compatible with efficiency in the administration of their affairs. Our property in Egypt is certainly of no less value than it was twelve months ago. As you will see by the report, the Directors of the Telephone Company of Egypt have placed £5,000 of debentures in Egypt at 6 per cent. interest. This we consider a fair rate taking into account the high rates of interest which are obtained in the East. As I have told you on several occasions, your Directors have always considered it mutually advantageous to both classes of shareholders to have only one class of shares, and they invited by circular the vendors' shareholders to meet the Board. As negotiations are in progress it is impossible for me to enter into details now. I am glad to say that at no exchange of the Company has there been a falling off in the revenue during the past year, and in several a very fair increase. I will detain you no longer, but will formally move the adoption of the balance-sheet and report now presented, and if any gentleman has any questions to ask I shall be happy to answer them.

The Right Hon. G. A. F. CAVENDISH BENTINCK seconded the motion.

Mr. POWERS thought it an extraordinary proceeding that such a large sum as had been mentioned should be taken out of the money earned by the Company and added to reserve fund, seeing that there was a reserve fund of 9s. a share uncalled on 220,000 shares. If a call were made for the development of the business he had no doubt that it would be readily responded to. It would in his own case, though he held over 1,000 shares, the majority of which had cost him 15s. each. He therefore considered it entirely unnecessary to form a reserve fund in the manner suggested by the Directors, by keeping so much of the earnings of the Company out of the shareholders' pockets. They had been waiting very patiently

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and now that the money could be paid to them they ought to receive it. He did not believe that the telephone business could be increased in Egypt and in the East, for they had already been at work between eight and nine years. He did not believe that a case had ever before been heard of a company which had earned £6,000 in a year and had never had a reserve fund, and then suddenly for such a fund to be created by keeping from the shareholders one-half of the amount they ought to receive. They had earned 5 per cent. and were to receive 3 per cent. Was such a proposal as that made because certain shareholders did not wish the 30 per cent. mentioned by the chairman to be reached, so that the vendors' shares should not come in for dividend? The vendors did nothing for the business. He repeated that the shareholders ought to receive now what the Company had earned. He did not consider that a reserve fund was required at all in such a business, and he thought the money was being kept back to provide for something that was going to come up that would settle the differences between a £1 share and an 11s. share.

The CHAIRMAN, in reply, said: I am sure that a call on the shares would be strongly opposed by every holder of the ordinary shares. When the present Board took office it was on the understanding almost that we would not make a call—certainly that we would try and carry on the business without making a call. The security of the uncalled capital of 9s. a share is a very heavy liability, and I cannot imagine that any holder of the ordinary shares should wish to be under the liability of that call being made. Mr. Powers said that there is no possibility of an extension of our business. Well, we have under consideration one or two plans in connection with which we may open up fresh places. The preliminary expenses of £3,000 have been written off this time. You see that £3,500 or £3,600 was brought into the account and £600 or £700 carried forward, so it is really more a question of account than anything else. Mr. Powesr remarked that the Egyptian Company had paid us £5,000 this year. That is very true, but it did not accrue in this year. It was a debt which had been owing since the formation of the company. Upon their placing those debentures that company paid us off this £5,000, which gives us the money in hand out of which we are now able to propose this dividend to you.

Mr. POWERS observed that his point was that no reserve fund was required, and there ought to be a substantial reason given for creating one.

The CHAIRMAN: I mentioned in my opening speech that the reason for a reserve fund in a great measure was to enable the Directors to push and extend the business should opportunities occur. We have now in view one or two probable extensions, and we have no money towards opening an exchange unless we form a reserve fund. The only other alternative would be a call, and I am sure from my experience that the great body of the shareholders—99 out of 100—would be strongly against a call. That was their feeling when we took office, and we have strained every effort to act up to that feeling.

The resolution was then put and declared carried by 18 to 17.

The CHAIRMAN then moved the following resolution:—

"That a dividend at the rate of 3 per cent., free of income-tax, for the year ended December 31, 1888, be declared on the paid-up capital of the Company other than the vendors' shares."

Mr. B. ST. JOHN ACKERS seconded the resolution, and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. FROST, Mr. Grëwing was re-elected a Director, Mr. Frost referring to that gentleman's large holding in the Company, and Mr. Thomas Lloyd was also re-elected to his seat at the Board.

On the motion of Mr. LEAN, seconded by Mr. FITZGERALD, the auditors, Messrs. Deloitte, Dever, Griffiths and Co., were re-elected.

The Rev. Mr. DAY then proposed a vote of thanks to the Chairman and Directors. The shareholders, he observed, might not all agree with the Directors in the policy of building up a large reserve fund; but it was, at all events, a safe policy. They all owed a great deal to the Directors who were steering the Company through its difficulties; and he, for one, was perfectly satisfied with their action.

Mr. SEAMAN seconded the motion, which was unanimously adopted.

The CHAIRMAN having replied, the meeting separated.

Reuter's Telegram Company (Limited).

Admiral the Right Hon. Sir J. C. D. Hay, Bart., K.C.B., presided over the twenty-fifth ordinary general meeting of the shareholders in this Company, held on the 17th inst. at the offices, Old Jewry.

The SECRETARY (Mr. F. J. Griffiths) having read the notice convening the meeting,

The CHAIRMAN said: In moving the adoption of the report and balance-sheet I must first express the great regret that Colonel Holland, who so long filled this chair, is no longer here to superintend the business of the Company. He has reached an age at which he is entitled to seek repose. He has been identified with the Company for twenty-five years. He felt that he was no longer sufficiently active to ensure regular attendance, and he was too conscientious to hold a post of which he feared he might not be able fully to discharge the duties. Our Managing Director is engaged in important negotiations with our Continental allies, and it would be indiscreet at present to analyse the figures of our accounts for the past year. They are of an abnormal character. Though the net result is not so favourable as could be wished, it is nevertheless not discouraging, as the Company had suddenly to face a loss of revenue, and could not at once take countervailing measures of economy at the agencies affected. The falling off in the profits belongs chiefly to the first months of 1888. We have also had special arrangements for news of an exceptional character in distant parts of the world; for instance, on the East Coast of Africa and in Samoa, countries from which a service of telegrams is very costly. We had further and alone most expensive telegrams detailing the progress of Mr. Stanley's expedition for the relief of Emin Pasha. Without boasting, it may satisfy the shareholders to know, as examples of our success, two instances which are very striking. In December last we announced the safety of Mr. Stanley in advance of all other sources of information, and our telegram was communicated to the House of Commons. Last Saturday week we announced with deep regret the calamity which had befallen the squadrons of Germany and the United States at Samoa, before any of the Governments concerned had knowledge of the disaster. In conclusion, we trust that the shareholders will continue to us the confidence we have enjoyed for so many years, and will accept our assurance that the negotiations now in progress will strengthen our position, by renewing and cementing our foreign alliances, upon which depend in great measure our immunity from what may be called fratricidal competition.

The motion was seconded by Baron de REUTER.

Mr. MAURICE GRANT stated that he was sorry to sound any discordant note at the meeting, but he happened to be one of the eight largest shareholders, and therefore he took a great interest in the Company apart altogether from sentimental notions. The world at large was indebted to Baron de Reuter for his efforts in the past in the direction of disseminating reliable information from all quarters with the strictest impartiality. It seemed to him that the question between the shareholders and the Directors was a very simple one. The figures he had analysed were very remarkable. The Company appeared to be a philanthropic society for the dissemination of news for the benefit of the public, and for the paying of salaries to various *employés* throughout the world. The result to the shareholders seemed to be the very last matter that was present to the minds of the Directors, though he said that with all respect. They appeared to have done business last year to the extent of £86,000 and in the pre-

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vious year to the amount of £91,000, and the net profit in the previous year was only £4,000 odd, while in the past year it had been only £1,200. They had carried on the whole business with the greatest possible skill and success, and all that the shareholders had got, after taking the commercial risks of the undertaking, was to receive £1,200 distributed among them. The current expenses, including salaries, &c., had been £20,000 ; in other words, it had taken 25 per cent. of all their receipts to pay for administration expenses. Either they were charging too little to the newspapers to whom they supplied information, or they were paying the *employés* unfairly. He knew that they had to meet competition, but their Company was at the top of the tree. They were only getting 1½ per cent., for the way the dividend was made up to 5 per cent. was by eating up the reserve fund. The pruning knife must be applied to the salaries, or their charges to newspapers must be increased ; the shareholders must live.

The CHAIRMAN : As the speech of the hon. gentleman has not been followed by a motion I think I need add very little to what I have said. But there is one point that is so creditable to our *employés* that it should be known, namely, that during the course of this year all the *employés* receiving over a certain amount, all excepting those having only very low salaries, have agreed to suspend 10 per cent. of their remuneration ; and the directors have only taken half the amount to which they are entitled. We had no desire to place that prominently before you. The payment is merely suspended because we trust that the time may not be far distant when the *employés* may receive what is their due. Mr. Grant, after his remarks, will be glad to hear that that point has not been neglected by the Directors, and that the various *employés*, with the most loyal feeling, at once accepted the arrangement.—The Chairman then put the resolution, and it was carried unanimously.

Baron de REUTER : I beg to propose the re-election of our retiring Director, Admiral the Right Hon. Sir J. C. D. Hay, who has been connected with our Company since its creation, and who is favourably known to every one.

The Hon. MARK F. NAPIER seconded the motion, which was carried unanimously.

The CHAIRMAN : I beg to thank you for re-electing me. The Directors have placed me, however unworthy, in the position lately occupied by our friend Col. Holland, and I shall do my very best to assist the Board in perfecting the arrangements which are now under consideration. I trust that at our next annual meeting we shall be able to present a much more successful report and balance-sheet.

On the motion of Mr. LOVEDAY, the auditors, Messrs. Welton, Jones, and Co., were next re-elected.

Mr. GRANT then proposed a vote of thanks to the Chairman and Directors, and the motion having been seconded, it was unanimously agreed to.

The CHAIRMAN : I am very much obliged to Mr. Grant and the shareholders for the confidence they have expressed in the Directors and the Chairman, who has already addressed them in acknowledging his re-election. I can only express my gratitude for the confidence which the shareholders have shown, and on behalf of my colleagues and myself. I can promise them that we will, as hitherto, do the best we can to promote the welfare of the Company.

The proceedings then terminated.

The Indo-European Telegraph Company (Limited).

The following is the report of the Directors of this Company for 1888, which will be presented to the twenty-second ordinary general meeting of the members, to be held at Winchester House, 50, Old Broad-street, London, E.C., on Monday, April 29, at 12 o'clock :—

The Board of Directors have to express their deep regret at the retirement from the chair, after an occupancy of seventeen years, of Colonel James Holland, and to express their satisfaction at the acceptance of that office by the present Chairman, Mr. J. Herbert Tritton.

The Company's revenue from all sources for 1888 amounted to £110,327. 7s. 7d., as compared with £104,290. 18s. 3d. for 1887, showing an increase of £6,036. 9s. 4d.

The expenses were on commercial and general account, £28,609. 12s. 9d.; on maintenance account £23,783. 11s. 10d., including £84. 17s. 8d. paid to the Russian Government ; total £52,393. 4s. 7d., as against £48,620. 15s. 3d., an increase of £3,772. 9s. 4d. Deducting the above expenses, taking credit for £2,694. 15s. 1d. brought over from 1887, and debiting income tax, there remains the sum of £59,283. 18s. 7d. From this amount £10,000 has been placed to reserve, and that sum, together with £10,625, amount of interim dividend, have to be deducted, leaving a balance of £38,658. 18s. 7d.

The Directors now propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year, carrying forward £6,783. 18s. 7d. to the credit of 1889.

It will be observed that the balance carried over is larger than usual. Provision has to be made, however, for extensive alterations and additions to the system which must be effected during the current year, and the recent interruption of both the Company's cables in the Straits of Kertch has also entailed exceptional outlay, so that the whole of the additional amount carried over will be absorbed. The falling off in the revenues derived from Indian messages upon the reduction of tariff, remarked upon in 1886 and 1887, continued during 1888, but fortunately has again been made up by other traffic.

The following Directors retire by rotation and offer themselves for re-election :—C. W. Earle, Esq., and J. Berenberg Gossler, Esq. The Auditors, Messrs. C. F. Kemp, Ford and Co., Public Accountants, retire and offer themselves for re-election.

The transfer books will be closed from the 15th to the 29th instant, both inclusive.

NEW COMPANIES REGISTERED.

BRITISH TANNING COMPANY.—This company has been formed with a capital of £70,000 in £1 shares, to purchase from Messrs. Worms and Balé, of Paris, their patent for the United Kingdom for an improved system of tanning by the aid of electricity, to work the patent process, and to grant licenses to tanners in Great Britain and Ireland. The process is stated to have been for the last six months in full work in France, and to cause a reduction in the cost and time occupied in tanning. It has been tested by experts whose reports accompany the prospectus. The intention is first to establish a tannery in London with twenty sets of apparatus, each capable of turning out about 140,000lb. of leather per annum, or 2,800,000lb. in all.

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended April 5, 1889, amounted to £3,407.

DIRECT UNITED STATES CABLE COMPANY.—The Board of this company has resolved upon the payment of an interim dividend of 3s. 6d. per share, free of income tax, being at the rate of 3½ per cent. per annum, for the quarter ending March 31, 1889, such dividend to be payable on and after the 26th inst.

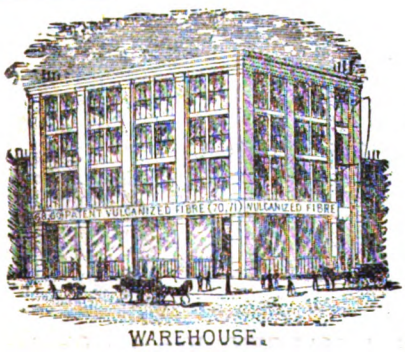
THE ELECTRIC DATE AND TIME STAMP COMPANY.—We are requested to state that there is no connection between this company, which was recently floated for the purpose of acquiring the patents of Mr. C. A. Randall's ingenious invention, and the "Time Stamp Company," against whom a winding-up order was granted by Mr. Justice North on Saturday last.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended April 5, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £2,171.

PERSONAL.—We are requested by Mr. Slater Lewis to state that he has resigned the managing directorship of the Telegraph Manufacturing Company, and that all correspondence intended for him should be addressed to his private house at Helsby, near Warrington.

——— Mr. G. J. Reed has retired from partnership with Messrs. W. H. Dingle and E. Stilliard, Victoria-street, Westminster, electricians.

THE NON-CONDUCTOR OF ELECTRICITY.



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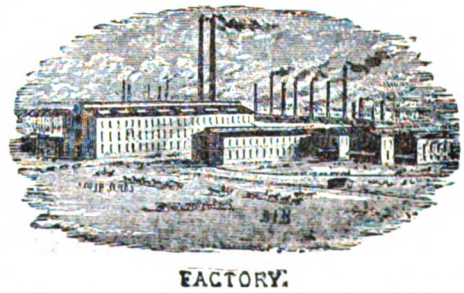
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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name.	Price, Wednesday, April 17, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending April 17, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£ 1,770,360	Stock	15/0	Anglo-American ..... xd	51½ 52½	3 18 5	Jan., Apr., July, Oct.	52	...
2,614,820	Stock	30/0	Do. Preferred ..... xd	87 88	4 10 11	,, ,,	88¾	86¾
2,614,820	Stock	...	Do. Deferred	19 19½	...	February	20	18¼
130,000	£10	5%	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13⅝	13⅜
112,900	£100	5%	Do. 5 per Cent. Bonds.....	101 103	4 17 1	January and July....	...	...
75,000	£100	3/0	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14¼ 14¾	6 2 0	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	1/7½	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October ...	...	...
60,710	20	3/6	Direct United States	10⅜ 10½	4 7 7	Jan., Apr., July, Oct.	10⅞	10¼
380,000	10	2/6	Eastern ..... xd	13¼ 13½	4 8 11	,, ,,	13⅝	13¼
270,000	10	3/0	Do. 6 per Cent. Preference ..... xd	14⅜ 15¼	3 18 8	,, ,,	...	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock ...	107 109	3 13 5	May and November.	108¼	108
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	4 10 11	February & August	...	...
250,000	10	2/6	Eastern Extension ..... xd and bonus	13¼ 13½	4 16 4	Jan., Apr., July, Oct.	13⅝	13¼
320,000	100	6%	Do. 6 per Cent. Debentures, 1891.....	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct.(Austrln.Gov. Sub.) Debs. 1900 ...	102 105	4 15 3	January and July ...	103	...
179,177	10	1/3	Globe Telegraph and Trust ..... xd	7⅜ 7⅝	4 15 1	Jan., Apr., July, Oct.	7 1/16	7¼
178,992	10	3/0	Do. 6 per Cent. Preference ..... xd	14⅜ 14⅝	4 2 1	,, ,,	14⅝	14⅜
150,000	10	5/0	Great Northern.....	15 15½	4 16 9	Jan., July, and April	15⅝	15¼
17,000	25	2/6	Indo-European.....	39 41	6 1 11	April and October ...	...	...
9,000	8	4/0	Reuter's	7¼ 7¾	5 3 2	April and October ...	7⅜	...
15,609	10	3/0	West African Telegraph.....	7⅞ 8½	...	...	7⅞	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	100	...
30,000	10	6/0	West Coast of America	9¾ 10¼	4 17 7	January and July ...	...	...
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅞ 2	...	...	1 1/16	1 1/16
34,563	10	12/6*	Do. 1st Preference 6%	11½ 12	...	April and October ...	11¼	11⅛
4,669	10	†	Do. 6 per Cent. 2nd Preference..... ...	12 13	...	...	...	...
45,181	15	6/0	Western Brazilian	12¾ 13¼	5 13 4	March & September	13	12¾
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	...	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	¾ ⅞	...	Yearly	¾	...
220,000	£1	3%	Oriental (11s. paid).....	⅜ ½	3 6 1	...	...	...
80,000	5	5/0	United.....	16¼ 16¾	4 9 7	June and December	16¼	16 7/16
55,000	5	...	United River Plate.....	5⅞ 6⅛	...	January and July ...	6⅛	5 15/16
			ELECTRIC LIGHT.					
23,003	5	...	Anglo-American Brush (£4 paid)	3 3⅛	...	...	...	...
23,692	5	nil.	Do. (fully paid)	4 4½	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2½ 3	...	...	2⅞	2¾
312,000	£	5%'86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42¼	41⅛
41,600	10	10/0	India Rubber, Gutta Percha, & Telegraph Works ...	17½ 18½	5 8 1	February & August	18¼	18 1/16

* Account arrears. † No dividend since May, 1880.

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NOTES.

It remains to be seen whether the action of the Postmaster-General in declining to sanction the proposed transfer of the licenses of the three leading Telephone Companies will or will not have any effect in preventing or even in retarding the amalgamation scheme. Seeing, however, that the license already in possession of the United Company virtually covers the whole of the country, it is difficult to see in what way Mr. Raikes' refusal can have any important bearing upon the issue. At the same time it unmistakably proves that he is not at all anxious to do anything to facilitate the transaction. But if the Postmaster-General means to hinder as far as he can the establishment of inter-urban telephony by the Telephone Companies, we trust that the Department over which he presides is prepared to undertake the work on its own account. That long distance telephony is bound sooner or later to be extended throughout the country is a proposition which we believe to be indisputable, and the public will see to it that the Post Office either does the work itself or stands aside (with its 10 per cent. royalty) whilst others undertake it who are able and willing to do so.

The evidence on behalf of the promoters of the Electric Lighting Provisional Orders was concluded before the adjournment for the Easter holidays, and the cases of the various local authorities concerned will now be taken as regards each company in order. The evidence reported in this issue is of considerable interest, particularly that relating to the lighting of the City.

An experiment described by M. J. Borgman (*Comptes Rendus*, April 8, p. 733) has an important bearing upon the explanation (which, however, is still wanting) of the remarkable discovery of M. Hallwachs, in which a beam of light seems to act as a conductor for an electric current. This latter experiment was described in *The Electrician* of February 8, 1889, p. 409, but in case any of our readers have forgotten it we may briefly remind them that a piece of metallic gauze (or a sheet of perforated metal) is placed parallel with but insulated from a second sheet of metal. The first is connected with the positive and the second with the negative pole of a battery, and in one of the leads a delicate galvanometer is placed. If now a beam of light be caused to pass through the gauze and to fall on the plate behind, a current is set up in the circuit and continues to flow as long as the illumination is maintained. It has moreover been shown that the action is due to the ultra-violet waves. Now, M. Borgman wanted to ascertain whether or not the effect was instantaneous—that is to say, whether the commencement and the cessation of the current was or was not simultaneous with that of the illumination. M. Borgman probably reasoned—though this he does not say—that if the beam acted in some sense as a conductor of the current the effect must be instantaneous, while if the phenomenon resulted from some secondary action it would probably go on increasing up to a certain point with the duration of the illumination, and it would also probably continue for a short time after the light had been cut off. His method of making the test was equally simple and ingenious. The light was interrupted at rapid intervals by means of a rotating disc with holes or slits, and he placed a telephone in circuit with the battery. It is, then, obvious that if the effect is instantaneous the telephone will produce a note corresponding in pitch to the velocity of the disc—if otherwise there will be silence. There was silence. A make-and-break in any other part of the circuit could be heard, but not in the ray of light. Hence we must seek for some secondary action on the surface of the plates to explain M. Hallwach's experiment.

At the last meeting of the Berlin Electrical Society, Dr. Werner von Siemens read a Paper on lead-covered cables, intended as a rejoinder to the recent remarks of Prof. Forbes. Dr. Siemens gave the explanation which has already been given at the Institute of Electrical Engineers as to the circumstances under which Prof. Forbes had been led to take a view which was no doubt unduly unfavourable. The following passage from Dr. Siemens' Paper is of interest:—

"That there is no reason to assume a general and considerable deterioration of insulation is proved by the measurements of cables of similar construction which have been laid by Messrs. Siemens and Halske in other localities. Ten cables of similar construction, of about 1,688 m. length, were laid in Munich in 1884 for lighting the theatre, and were tested on the 9th March of this year; nine of these cables showed an average insulation of 50 millions of ohms per kilometre, whilst one cable showed an inferior insulation, which, however, has not affected the working yet. Immediately after being laid, these cables had an average insulation of 160 millions of ohms per kilometre. This diminution of insulation, which is practically of no account whatever, is only apparent, since the cable terminals are situated in unheated damp rooms, and could not be carefully dried and insulated, as would be required for measurements of such high insulations."

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Our New York correspondent describes a device due to Prof. Elihu Thomson, by means of which a constant (mean) alternating current may be maintained in the secondary circuit of a transformer supplied with constant potential in the primary. The arrangement is an interesting one, but it does not seem to be very different in principle from the employment of "choking coils" in the primary and secondary circuits. If suitably adjusted this would at any rate have the same effect. The object aimed at is apparently to facilitate the use of arc lamps on transformer circuits. For our own part we think that the proper way of dealing with this problem is to adapt the mechanism of the lamp itself to the particular conditions under which it has to work. This has already been done with perfect success by at least one English firm, and we should strongly recommend all makers of direct-current arc lamps to turn their attention to this matter, if they have not already done so, without loss of time.

In the laboratory of the Sorbonne, MM. Pellat and Potier have made a new determination of the electro-chemical equivalent of silver by means of the absolute electro-dynamometer constructed two years ago by M. Pellat and presented by him to the Société de Physique. Two experiments, conducted with all known precautions, gave 1·1189 and 1·1195 respectively as the number of milligrammes of silver deposited by one ampere in one second. The mean of these figures is 1·1192. The previous determinations are :—

Kohlrausch	1·1183,	Mascart	1·1156,
Rayleigh	1·118,	Pellat & Potier	1·1192.

It is perhaps worth noting that if Mascart be allowed a weight in accordance with its wider divergence, then Rayleigh's value is almost exactly the mean of the four. It is, therefore, permissible to look upon this latest determination as a confirmation of the result previously accepted in this country.

We have received the following communication from a correspondent :—"The Electro-lunatic presents his compliments to the Editor, and begs to inquire, through the columns of *The Electrician*, whether the eminent firm of electrical engineers who are tendering to light the town of Cork with 16-candle lamps, using only 25 watts per lamp, are prepared to supply the public in general with a similar article; and, if so, whether they will guarantee that the lamps running under these conditions will last as long as a thousand seconds?"

When the Paris Municipal Council proceeded, a few days ago, to the election of five technical members of the Commission de l'Usine Municipale d'Electricité, it was found that M. Hospitalier, the well-known editor of *L'Electricien*, was amongst those elected. Upon this, M. Faillet, a member of the Council, remarked that it was a great pity *(il est fâcheux)* that a gentleman who was understood to have recommended the employment of English machines should be on the Commission. M. Faillet proceeded to remark that he regretted that they had not preferred some one who would have appreciated and would have made known the superiority of the French machines, "a superiority recognised by the whole technical world." M. Hospitalier wrote to M. Faillet politely inquiring what he meant by this, and asserting that his opinions of the merits of electrical machines were founded upon scientific grounds, and not on the question of nationality. Now, we do not know whether or not M. Hospitalier would agree with us—M. Faillet certainly would not—but for our own part we consider the French manufacturers to be singularly behindhand in the design of dynamos and motors. German and American makers, to say nothing of the English, beat them easily. Up to the present time all the more important central station work that has been carried out in France has been done by foreigners, such as Ganz and Co., Thomson-Houston, Edison, Ferranti, and Crompton, whilst we have yet to learn that any central station work has been carried out abroad by French firms. In the country of M. Gramme this is not a little singular. We believe, however, that the reason is exemplified by M. Faillet, who believes that the French dynamos must be the best for no better reason than that they are French.

The April number of *Blackfriars, The Post Office Magazine*, contains a bright little sketch, by Mr. R. C. Day, of race meetings from a telegraphist's point of view. The cause of the demoralisation of the turf has been the subject of considerable discussion of late, and we are inclined to think that the real culprits have been completely overlooked. It is very evident from Mr. Day's little article that the turf, as at present instituted, could not exist without the telegraph, so that the Post Office and the Wheatstone Automatic must share the blame of this demoralisation between them. The delinquents, however, certainly suffer for their sins, for a more appalling picture than the sudden charge of the excited turfites on the Epsom Grand Stand office after the Derby it is impossible to imagine; and when we add that close upon 10,000 messages are despatched from this office alone in the course of the day, we think it will be generally agreed that the punishment is proportionate to the offence. Mr. Scudamore used to say that the inside of the Grand Stand office immediately after a great race is the best place to study "varieties of hands." That witty gentleman probably had in his mind the "legs" as well.

The Committee for the Suppression of Electrical Quackery sends us a copy of a pamphlet entitled "An Exposure of Electrical Quackery," containing a reprint of the correspondence and editorial remarks upon this distressing subject which have from time to time appeared in the columns of our contemporary the *Electrical Review*. The Preface states that the object of the pamphlet is "to enlighten the Press and the Public upon the nefarious practices of the vendors of bogus electrical appliances." This is a movement with which we are in the fullest sympathy, and we trust that the Committee will feel themselves strong enough to bring the Chief Impostor of the Fraternity before a Court of Law. As regards the behaviour of the daily press in this matter, it is difficult to find words strong enough in condemnation. We would suggest further that steps be taken to bring the matter to the notice of Parliament—we are not at all sure that quack medical advertisements might not be made the subject of legislation.

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MEANWHILE we are also glad to learn that active steps are being taken with the same object in another direction. Those interested in the medical aspect of the case would do well to place themselves in communication with the Editor of *Brain*.

Sir John Pender.—Last week's issue of the *Municipal World* gives by way of supplement an excellent ink-photo portrait of Sir John Pender, K.C.M.G., illustrating one of that paper's series of "Sovereigns of Labour and Industry."

Modum.—Some English capitalists, says *l'Electricité*, have purchased a powerful waterfall near Modum (Norway) for £6,000. The power available amounts to about 4,000 horse-power, and it will be used for electrical installation purposes.

Plymouth.—Steps are being taken in this town by the House-to-House Company to form a local electric lighting company, and we understand that the Corporation are disposed to consider favourably the question of the lighting of the streets by electricity.

St. George's (Hanover-square) Vestry.—At a meeting of the Works Committee of this Vestry on Tuesday last week a letter from the solicitors of the Metropolitan Electric Supply Company was read, announcing the intention of that company to erect a central lighting station in Eccleston-square, Pimlico. It was decided to take no action in the matter.

Electric Lighting in the Inner Temple.—The elaborate preparations made some time since for the purpose of illuminating the chambers and offices in the Inner Temple with the electric light have now been definitely abandoned, and the extensive excavations made in the Inner Temple-gardens for the reception of plant and machinery are now being filled in.

Norwich.—The Corporation of Norwich have adopted the following resolution:—"That this Council endorse the application of Messrs. Laurence, Paris and Scott (Limited) to the Board of Trade for a Provisional Order similar to that adopted by the Ipswich Town Council, and that if the order is obtained this Council will further in any way that is lawful the carrying out of electric lighting in this city." During the discussion it was stated that the lease of the New Mills would expire shortly, and that the water-power there, which was equal to 30 horse-power, would be sufficient to light all the open spaces in the city.

Deaths by Lightning.—At the meeting of the Royal Meteorological Society, on the 17th inst., a Paper "On the Deaths caused by Lightning in England and Wales from 1852 to 1880, as Recorded in the Returns of the Registrar-General," was read by Inspector-General R. Lawson, LL.D. The total number of deaths from lightning during the 29 years amounted to 546, of which 442 were of males and 104 of females. In consequence apparently of their greater exposure the inhabitants of rural districts suffer more from lightning than those of towns. It appears also that vicinity to the west and south coasts reduces the chances of injury by lightning, and that distance from the coast and high land seems to increase them.

Electric Light at the Mysore Palace. — The Maharaja's palace at Mysore is, says the *Indian Engineer*, soon to be lighted throughout with electric lights. The first storey of the palace will contain 62 lamps and the second 120. They are all to be incandescent lamps of 16 candle-power. The palace will be also lit with 6 arc lamps of 2,000 candle-power each, while at the very top of the palace will be the largest projector lamp in India, of 5,000 candle-power, which is intended to throw a light from 60 to 80 miles distance, and cast a shadow which, if thrown up, will be seen at Madras, Ootacamund, etc. The lights will be run off 53 accumulators. The arrangement of lighting by electricity has been calculated to be a saving to the exchequer.

Philosophical Society of Glasgow.—At the last meeting of this society, which was held in the Natural Philosophy Class Room at the University, Sir William Thomson gave a most interesting series of experiments with the gyrostat in its various forms, and by means of them he was enabled to demonstrate many important principles of physical and mechanical science. (The learned professor gave the same demonstration on the night of the 19th inst. under the auspices of the Natural History and Philosophical Society of Belfast, his native town.) Mr. J. T. Bottomley, F.R.S., subsequently explained the methods followed in measuring the electric resistance of glass plates. He also exhibited two Leyden jars which had been broken by a powerful discharge of static electricity, and pointed out the curious properties of the fracture.

The Lighting of the City.—At the last meeting of the City Commission of Sewers, Colonel Harwood, the Engineer to the Commission, reported that under permissions given by them two experiments in public lighting were now being carried out in the City—the one by the Gas Light and Coke Company and the other by the Defries Safety Lamp and Oil Company. Both experiments were at the expense of the applicants, and were to last one entire year. The streets in which they were being conducted were Cheapside, Poultry, Mansion House-street, Threadneedle-street, Cornhill, Royal Exchange-avenue, King William-street, Princes-street, Queen Victoria-street, Newgate-street, where 112 new lamps of the Gas Light and Coke Company were being tried, and in Holborn-viaduct and Holborn-circus, where 30 petroleum oil lamps of the Defries Company were in operation.

The Electric Light in Johannesburg.—A correspondent writes us from Johannesburg as follows:—"The property of the Robinson Gold Mining Co. has recently been lit by electricity. The installation comprises a dynamo driven by one of Fowler's compound high-pressure engines, and about 40 16 candle-power incandescents and four 800 candle-power arcs worked in parallel current. Great difficulty was experienced in adapting this plant for the work of the mine, as it was originally supplied for lighting the Globe Theatre, and had been left for several months in the open before being used. The cables, with the exception of a few hundred feet, were all made on the spot, of $\frac{7}{16}$ copper wire procured in the town. Over 2,000 feet were made in this manner. Switches also had to be made in Johannesburg. The whole of the work was carried out by Mr. T. Miles, of Johannesburg."

Strand District Board.—At a meeting of this Board last week Mr. Lemon said there had been a meeting of the Lighting Committee, when they found it was exceedingly important that certain re-arrangements should be made with regard to the agreement which had been entered into with the Metropolitan Electric Supply Company. He asked the sanction of the Board for the erection of another station of supply, so he would move "That the committee be empowered to agree to a supplemental form by substituting a station in Cecil-street for the one in Sardinia-street, and for such other alterations not varying substantially the agreement as the committee shall approve." If this were not done another year's delay would be incurred before they got the electric light in the district. After some opposition the proposition was agreed to. At the same meeting of the Board it was moved that the Board oppose the London Central (Subway) Railway Bill, but after a debate the matter fell through.

The Chancellor of the Exchequer upon the Post Office.—The following notice appeared in the Post Office Circular last week:—"The Postmaster-General has much pleasure in bringing to the knowledge of the officers of the department the following expressions of high commendation which were used by the Chancellor of the Exchequer in his Budget speech in the House of Commons on the 15th instant:—'So far as he (*i.e.*, the Chancellor of the Exchequer) could exercise any influence over the Post Office he should encourage them to improve their service. He should be sorry to take a churlish view of the splendid efforts of one of the most successful departments that ever existed—a department full of energy, which deserved the great thanks of the country for the magnificent manner in which it had conducted a most complicated service.' Mr. Raikes feels sure that this public appreciation by the Government of their labours will gratify and encourage the officers of every rank and class throughout the department."

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Field-Telegraph Cavalry Corps.—An order emanating from the headquarters staff of the French army has just arranged the organisation and laid down the duties of the proposed Mounted Telegraph Corps. A telegraph troop, consisting of trained operators, is to be formed in each regiment of cavalry in the French army. The troopers composing this corps are to go through a special course of field telegraphy for twenty days every year at one of the three centres at Versailles, Lurréville, and Lyons; in addition to which they are to be employed on telegraph work when in garrison and on the occasion of the annual manœuvres. In the field every advanced party and reconnoitreing expedition is to be accompanied by portable telegraph apparatus, and the proper complement of operators. The special duty of these telegraphists is to keep up communication with the main body of the cavalry as long as possible, either by heliograph or by means of the existing lines. The telegraphists with the main body have to assist in communicating with those of the advanced detachments and to transmit messages to the general commanding the cavalry division.

M. Cornu on the Incandescence of Shooting Stars.—In a Paper on shooting stars recently read before the Académie des Sciences by M. E. Minary, he argued that the incandescence of these bodies cannot be explained by the transformation of motion into heat. The gases being perfectly elastic bodies, and in the upper atmospheric regions in an extremely rarefied state, heat cannot be produced by the shock of bodies endowed with great velocity and impinging on perfectly elastic molecules capable of receiving the motion and acquiring the velocity of those bodies; in this case the movement is communicated, not dissipated or transformed to heat. The reading of the Paper was followed by some observations by M. Cornu, who remarked that the illumination of the trajectory of the shooting stars might be attributed to a development or a discharge of static electricity without any considerable rise of temperature; as implied by the incandescence of detached particles of meteorites. This would agree with the spectral observations made on the shooting stars, and would lend support to the view that certain cosmic phenomena, such as auroras, the zodiacal lights, comets, solar protuberances, &c., are electric manifestations analogous to those that are so easily generated in rarefied gases.

Milianah (Algeria).—The municipal central lighting station at Milianah (Algeria), which has now been in operation some three months, has proved a decided success. Motive power is obtained from a Meunier turbine which runs at 400 revolutions per minute, and which is driven by a 140ft. waterfall. Two Manchester dynamos, running at 600 revolutions, each supply a current of 210 amperes at 110 volts. The station is situated in a mill on the mountain side, and is a little way outside the town. The public lighting includes forty 20 candle-power and twenty-five 50 candle-power incandescent lamps, besides a few 200, 300, and 500 candle-power lamps. The cost of the plant, cables, and buildings amounted to 55,000fr. The estimated working expenses, including interest and depreciation, amount to 8,000fr. per annum; but as the receipts from private consumers are estimated at 7,500fr., the annual charge for working and maintenance is reduced to 500fr. As, however, the number of consumers is increasing, the station may, on a moderate estimate, be expected to pay its way and light the streets for nothing. Previous to the introduction of the electric light the 56 petroleum lamps lighting the town cost 6,000fr. per annum. The charge for an incandescent lamp is 36fr. per lamp per annum.

Edisoniana.—The following observations are made by our contemporary *Ironmongery*. We quote the passage because we think there is a good deal of justification for the view therein maintained:—

"Nothing succeeds like success, except elaborate and unstinted puffing. A recent issue of the *New York Tribune* contained a contribution to the Edison "boom," which is not only a very characteristic specimen of the well-known style of American journalism, but which comes very near to placing its hero upon a pinnacle quite out of sight of ordinary humanity. Mr. Edison has shown great ingenuity and a remarkable cleverness in promptly utilising the ideas of others, while both he and his admirers, on either side of the Atlantic, are amongst the most skilful advertisers of this pushing age. We fail to see, however, that he is entitled to the honours so eagerly claimed for him, which are the due only of the great original investigators into Nature's secrets; and if there is any truth in the statement which accompanies this last puff, that nearly one-third of the entire space allotted to the United States in the Paris Exhibition is to be devoted to an 'Edison exhibit,' we may admire the enterprise displayed while we deprecate the display. Time will deal justly with Mr. Edison. He will have no complaints to make that a hurrying and indifferent world has passed his genius by unnoticed, and left its recognition to posterity. But we greatly doubt if he will always subtend a third of our interest in the industrial progress of the American States."

Copying Drawings, &c.—A hint that may be useful in engineering drawing offices is given in the *Deutsches Baumgewerbes-Blatt* concerning a new method of copying drawings. Any kind of opaque drawing paper in ordinary use may be employed for this purpose, stretched in the usual way over the drawing to be copied or traced. Then, by the aid of a cotton pad, the paper is soaked with benzine. The pad causes the benzine to enter the pores of the paper, rendering the latter more transparent than the finest tracing paper. The most delicate lines and tints show through the paper so treated and may be copied with the greatest ease, for pencil, Indian ink, or water colours take equally well on the benzinised surface. The paper is neither creased nor torn, remaining whole and supple. Indeed, pencil marks and water colour tinting last better upon paper treated in this way than on any other kind of tracing paper, the former being rather difficult to remove by rubber. When large drawings are to be dealt with, the benzine treatment is only applied in parts at a time, thus keeping pace with the rapidity of advancement of the work. When the copy is completed, the benzine rapidly evaporates, and the paper resumes its original white and opaque appearance without betraying the faintest trace of the benzine. If it is desired to fix lead-pencil marks on ordinary drawing or tracing paper, this may be done by wetting it with milk and drying in the air.

Folkestone.—We hear that the Folkestone Town Council have decided on entering into a contract with Messrs. Crompton and Co. to light the western portion of the town with electricity for five years. The present cost of lighting that part of the town by gas is £1,034. 3s., with 4,312 candle-power, whilst the cost to light the same area by electricity will be £1,032, with 51,600 candle-power. Messrs. Crompton have guaranteed the efficiency of their arc light under very heavy penalties; for it is stipulated in their agreement that, should any of their lights fail, a sum of £62 each should be forfeited—the actual price charged for each lamp being £24. Although the scheme has passed the Council, and has been practically signed and sealed by them, there still remains a difficulty with the Gas Company. Their agreement with the Corporation does not expire until July, 1890; and unless they are willing to allow the agreement to be cancelled or altered Messrs. Crompton's contract will have to be delayed.—At a meeting of the Folkestone Town Council last week the Town Clerk read a letter from the Secretary of the Gas Company, in answer to the request of the Electric Light Committee that the company should surrender the lighting of 200 ordinary, 38 special, and 10 Bray's lamps in the western district of the town with a view to the substitution of the electric light. The Secretary stated that the company was not prepared to assent to any modification of or departure from the lighting contract existing between the Corporation and the company. The letter was referred to the Electric Lighting Committee.

A Dynamo Mishap.—"W. F. G." writes as follows to the *New York Electrical World*:—

"In the operation of machinery of any kind mishaps are liable to occur at any moment; but if we are familiar with the signs and noises that sometimes precede such accidents they may frequently be avoided in time. I was forcibly reminded of this by a mishap which occurred in the station under my charge. The accident was rather unusual, inasmuch as it is the third of its kind to happen among almost seven hundred machines of this type put out. The apparatus referred to is an alternating machine, and had run eleven months without any trouble whatever. A few nights prior to the breakdown we heard a very peculiar noise, which came direct from this machine, and which may be compared to the noise made by a small jet of steam being suddenly turned loose and gradually diminishing to nothing. We could find nothing to cause

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this noise, and were considerably puzzled over its origin. But when the final breakdown came it was easily understood that the noise was caused by the breaking of a *few* strands of the small wires composing the bands, the loose ends raking over the magnet cores causing the noise described. But when the band proper gave way the result can be more easily imagined than described. The broken band being in the centre, it, of course, caught on the field-magnet cores, and bunched up and stripped the armature of its coils. These coils wedged between armature and fields so firmly as to stop the engine before the throttle could be closed. The only parts of the machine thrown about were small pieces of cardboard and mica used in insulating the coils from the armature. Had I removed the armature on first hearing the noise, I would probably have averted the accident, and I would suggest to readers of the *Electrical World* who operate any type of alternating machine to remove the armature and examine the same *at once* under similar circumstances, so as to avoid serious and expensive accidents.

Fort Augustus.—The following details of the installation at the Benedictine Abbey at Fort Augustus, which was mentioned in our last issue, may prove of interest:—The engine is a 10-horse (nominal) long-stroke horizontal, made by Messrs. Robey and Co., Lincoln, and fitted with Richardson-Rowland patent triple expansion gear, controlled by a Richardson-Nevile electrical governor. The boiler is a 10-horse Cornish one, fitted with Perret's patent furnace for burning dust-fuel. There are 76 Drake and Gorham accumulators, capable of supplying 100 lights for a period of 10 hours. The dynamo is an 18-unit plain shunt-wound Elwell-Parker machine, and by itself is capable of supplying from 250 to 300 lights, so that, with the aid of the accumulators, provision is made for from 350 to 400 lights. The accumulators, when feeding the lamps by themselves, are controlled by the Nevile patent regulator, which automatically keeps the electromotive force in the buildings constant. An automatic switch is also fitted, which connects the dynamo with the battery-circuit as soon as the electromotive force of the former arises above that of the latter; and, in the event of the electromotive force of the former dropping below the required amount, immediately disconnects it from the battery-circuit. There are about 400 lights distributed over the various rooms and offices of the buildings. The majority of the lights are pendants, but in the monastic library and other kindred rooms portable reading lamps are fitted with wall attachments, and in most of the monks' cells and senior students' rooms a pulley arrangement admits of the light being carried to any part of the room. The installation has been carried out by Mr. Nevile, of Wellingore, near Grantham.

Lighting of the Garrick Theatre by the Metropolitan Electric Supply Company.—The Garrick Theatre, which was opened on Wednesday, is lighted throughout by electricity supplied from the mains of the Metropolitan Electric Supply Company, there being in all about 1,000 lamps in the theatre. It had been originally intended to light it from Sardinia-street, but as this station is not ready it was decided to supply the electricity from the engines situated at the Hotel Victoria, which have been discarded on the hotel having been connected to the mains from the Whitehall station. It will be understood that the distance from the Whitehall station to the Garrick Theatre was too great for the supply of the low-pressure current which is there generated. Owing to the very recent completion of the theatre no full trial of the lighting was possible until Friday, the 12th inst.; it was then found that the regulating arrangements of the engines were not sufficient to ensure a steady light throughout the rapid changes required during a theatrical performance. On Saturday morning Mr. J. E. H. Gordon determined to erect an accumulator station at the theatre. For this purpose a workshop was hired in a court behind St. Martin's-lane which adjoins the back of the theatre, and 264 31L cells were ordered from Messrs. Elwell-Parker, together with the necessary switches and regulating apparatus. The total weight of these cells is something over 20 tons. A drawing of the shelves to carry them, which are necessarily of a very massive description, was handed to Messrs. Hobbs, of Croydon, on Monday night, the 15th inst. These shelves, which contain about 10 tons of timber, were completed, put together at Croydon, taken to pieces, sent up and erected and finished by eight o'clock on Thursday morning. The erection of the batteries, which had meanwhile been delivered by Messrs. Elwell-Parker, was then begun, and was completed on Sunday night. They were charged throughout Monday and Tuesday, and were used with perfect success throughout the whole of the final rehearsal on Tuesday night and during the performance on Wednesday. It is believed that this is almost a unique feat in the history of rapid electrical engineering. The result of using the batteries is to keep the light perfectly steady.

Paddington and the Electric Light.—At a meeting of the Paddington Vestry on Tuesday the Electric Lighting Joint Committee recommended that "as the inquiry before Major Marindin, the Board of Trade Inspector, is still being proceeded with, and much valuable information as to the electric lighting is being elicited, any decision on the question of electric lighting of this parish by the vestry be postponed until the before-mentioned inquiry is concluded, and that the solicitor be directed to instruct counsel to present the case of the parish before the Inspector, Major Marindin." Mr. Judge rose to move an amendment. The result of carrying the recommendation would be that the vestry would be driven into a corner, as they were last year, and would be at the mercy of any company which might be most pertinacious in pushing its claims on the parish. It was distinctly provided some time ago that Prof. Forbes should report before the end of March, so that the vestry might formulate action before the May elections. If the vestry undertook the work as recommend by Prof. Forbes it would involve the expenditure of a large sum, and if on the other hand a company introduced the light, a monopoly might be created. Seeing that the matter was so important, he was not satisfied with the manner in which the Lighting Committee had dealt with it, and had given notice of a motion he intended to propose as an amendment. The committee were instructed to consult Prof. Forbes, and he had prepared a report, and upon that report some action should be taken. He thought the course they should adopt was to obtain some proposals from companies for doing the work, as he considered the undertaking too great for the vestry, if they could obtain the same advantage by private enterprise. He would move, therefore:—"That while the report of Prof. Forbes, F.R.S., M.Inst.C.E., shows that the vestry might secure many advantages to the borough by itself undertaking the introduction of the electric light, it would be better to secure these advantages by means of private enterprise, rather than for the vestry to adopt the principle of municipal trading on so extensive a scale." After a long discussion the amendment was lost, and the recommendation of the committee was adopted.

A SONG AFTER LAMPLIGHT.

(As sung by the Swinburnian Gas-share-holder on reading a report of the inquiry now being held as to the working of the Electric Lighting Acts of 1882—1888).

The end has come of all our fume and fretting,
As, darkness deep'ning round us, O my brothers,
We watch this sun of ours sink to its setting
To herald an uprisen light to others.

No more the stream from poisoning meter seething
Shall stay and stint the stifling air around us,
Till it with breath of death, in this our breathing,
Through sense of cheating choke and gasp confound us.

No more! For spite the living load of blunder
That crushes life from every golden measure,
The "main" at length is riven—rent in sunder,
And scattered to the winds its hoarded treasure!

So hail, to fair Electric Installation!
No fear that it will find us mute to meet it.
Invaded, we will yield it habitation
And grovel in our gratitude to greet it.

Hail to its shares! and what, then, of those others?
"*Gas* will go down." Nay, class me not with jokers,
When I advise you, strongly, O my brothers!
To wire that one word "sell" straight to your brokers.

—*Punch.*

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THE USE OF THE INTEGRAPH IN DETERMINING SOME PROBLEMS IN ELECTRO-DYNAMICS.

BY L. B. ATKINSON.

The earlier workers in the modern field of heavy electrical engineering for lighting purposes made use to a large extent of alternate-current dynamos, principally, no doubt, because of the difficulties with the commutator which want of knowledge how to design a continuous-current generator gave rise to. It is interesting to speculate whether, had the alternate-current generator continued in the forefront, the modern electric generator would have made the strides it has done; or whether, rather, the double difficulty of dealing theoretically with the magnetic problems and the problems of variable currents would not very seriously have delayed the advance by preventing all but a few professed mathematicians from attempting their solution other than by lengthy and bewildering experiment. As the course of events has gone, however, electricians have grown familiar with magnetic problems before they have been called upon to attack the more complicated questions connected with periodically variable currents.

At the present time nearly all theoretical considerations of the latter subject are based upon the assumption that the law governing the variation of E.M.F. in the circuit is a *simple* harmonic function of the time, and, if this assumption be objected to, the objection is met by reminding the critic that Fourier has demonstrated that any function can be expressed as the resultant of a series of harmonic functions with different periodic

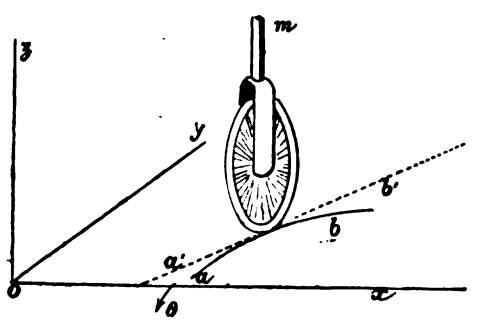

Fig. 1.

times; but writers scarcely stop to see whether their results would not be wholly modified if they considered some of the terms of the Fourier series which they neglect.

Recently, at a discussion at the Institute of Electrical Engineers, Prof. Ayrton gave the result of calculating the current in a circuit acted upon by an E.M.F. following a particular law of variation by a Fourier series taken to nine terms, the result of which was, it may be believed, so far different from what most engineers would have *à priori* guessed at as to convince them of the desirability of arriving at a less tedious, and, probably to most, less impossible, method of solving the problem fully and correctly.

The question that has to be answered is this:—Given an electric circuit of known material and shape, with or without an iron core; given also an impressed E.M.F. varying periodically according to some curve, we can arrive at a solution which will enable us to express graphically, and hence arithmetically, the periodical variation in the current.

If E be at any moment the impressed E.M.F.,
C the current,
R the ohmic resistance of the circuit,
L the coefficient of self-induction,

it is well known that the current at every instant satisfies the differential equation

$$L\frac{dc}{dt}+CR=E \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The object of the present article is to show how this question may be simply solved by mechanically integrating the above equation instead of going to the immense labour of first algebraically integrating it and then working out the numerical values.

Before going right into this, however, it is well first to describe the principle on which such an integrator is based. If a small roller, with a tolerably sharp edge to prevent it slipping sideways, be supported on a horizontal axis, and moved over a horizontal surface in any direction, its point of contact with the surface will trace some curve, and the projection of the plane of the roller on the surface is a line which is at every point tangential to the curve being traced. Thus, in Fig. 1 the roller is supported on pivots, and being travelled over the surface traces some curve $a\ b$ to which $a_1\ b_1$, the projection of the medial plane of the roller, is tangent.

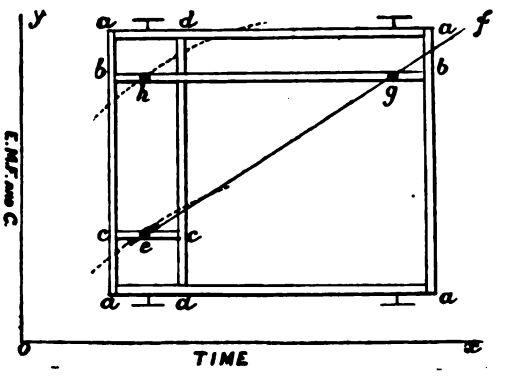

Fig. 2.

Treating this curve by the use of the co-ordinates O X and O Y, if this line, which is a tangent to the curve, makes with O X an angle θ whose trigonometrical tangent is tan θ,

then $\frac{dy}{dx}$ is the instantaneous value of $\frac{y}{x}=\tan\theta$.

Hence, with such a roller, if we know the law of the instantaneous values of the tangents of the angles which its plane projected makes with the axis O X, by *suitably turning the vertical pivot m*, to satisfy this law, we can draw the curve which is required.

It is further to be noted as a property of such a roller that, if it be moved in any direction $a_1\ b_1$, this motion is a resultant of a motion parallel to O X and a motion at right angles parallel to O Y, and that if the pivot m be constrained by guides so that

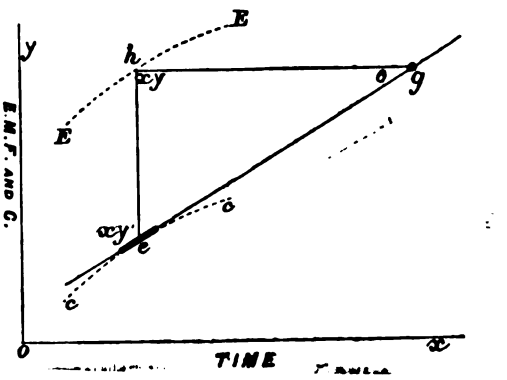

Fig. 3.

it can move in two directions at right angles parallel to O X and O Y respectively, if the pivot is moved parallel to O X, the wheel being inclined at an angle to O X, the wheel and pivot will move on the second guide in a direction parallel to O Y, the reaction between the wheel and paper being the impelling force.

This preliminary explanation is given in order to make what follows clear to any not familiar with mechanical integrator mechanisms; those who are familiar with such will observe that it is the non-slipping class of integrator which is adapted, which has been used to a considerable extent by M. Abdank Abakanowicz and Mr. Vernon Boys in various apparatus.

Proceeding analytically, the construction of an integraph on these principles may now be described, after which it will be

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shown that the apparatus does satisfy the conditions of equation (1) preceding—that is, that the roller does trace the current curve when the law of variation of E.M.F. is given.

Fig. 2 is a skeleton drawing of such an integraph; $a\,a\,a\,a$ is a rectangular framework carried on rollers constraining it to move only in direction parallel to $o\,x$; $d\,d$ is a cross-bar forming with $a\,a$ an internal frame in which a slide, $c\,c$, can freely move parallel to $o\,y$; $b\,b$ is a bar sliding in $a\,a$, also parallel to $o\,y$. This bar carries at h a tracing-point, and at some point, g, a pivot which can be fixed at any point on $b\,b$, and which is free to move round its vertical axis when so fixed; $c\,c$ carries the vertical pivot of an integrating roller—the head of this pivot is controlled by what may be termed the tiller $e\,f$ passing through the pivot g and free to slide in g.

Referring to Fig. 3, which shows the triangle $e\,h\,g$ dissociated from the framework, the movement can be analysed.

Suppose the tracer h is following some curve $e\,e$ by the component movements of the frame parallel to $o\,x$ and the slide b parallel to $o\,y$, the wheel e traces some curve $c\,c$. At every instant the plane of the wheel projected is tangential to this curve, and the tangent line makes an angle θ with $o\,x$, and the following relations hold good :—

$$\frac{d\,y_1}{d\,x_1} = \tan\,\theta = \frac{e\,h}{h\,g} = \frac{y - y_1}{h\,g}.$$

Now let the curve $x\,y$ represent the relation of magnitude of E, the impressed E.M.F., and t the time to such a scale that $y = \frac{E}{R}$; let also $h\,g$ be chosen to represent to a proper scale the ratio $\frac{L}{R}$,

then

$$\frac{d\,y_1}{d\,x_1} = \frac{\frac{E}{R} - y_1}{\frac{L}{R}},$$

and it is only necessary to write C the current and t the time in place of y_1 and x_1, giving

$$\frac{d\,c}{d\,t} = \frac{\frac{E}{R} - C}{\frac{L}{R}},$$

and transform thus : $L\frac{d\,c}{d\,t} + C\,A = E,$

to show that the curve traced by the roller is the curve of current required.

By this form of integraph, then, all problems connected with a single electric circuit in a non-conducting medium may be solved. It remains to show how, by extending the principle here indicated, the problems of two circuits, each with known electric and magnetic constants, may be treated.

(To be continued.)

MÜLLER AND LAHMEYER'S DISTRIBUTING SYSTEM.

In an editorial note we recently referred to the system of direct-current distribution which was recently brought before the Elektrotechnisch Verein, Berlin, by Herr Lahmeyer. As we find that considerable interest is being taken in the system the following additional details are given: — In Fig. 1 E is the main driving pulley of the engine working the dynamo D, which supplies current to main station leads A and B. From these various feeders are taken off to different points in the network. One such pair of feeders are shown at F, and the object is to maintain a constant potential at the far ends of these feeders, with varying currents, and consequently varying drop of potential along the feeders themselves. To attain this a supplementary small dynamo, driven from E, is introduced into the feeder. The magnets of this machine are compound-wound, as shown in the diagram, the whole current in the feeder passing through the armature and series winding, while there is also a second fine wire coil coupled direct on to the main station leads. The two windings are so adjusted in opposition to each other that when practically no current is passing through the feeder the small dynamo acts as a motor, and by its back E.M.F. cuts down the E.M.F. at F to that required to be kept constant at the

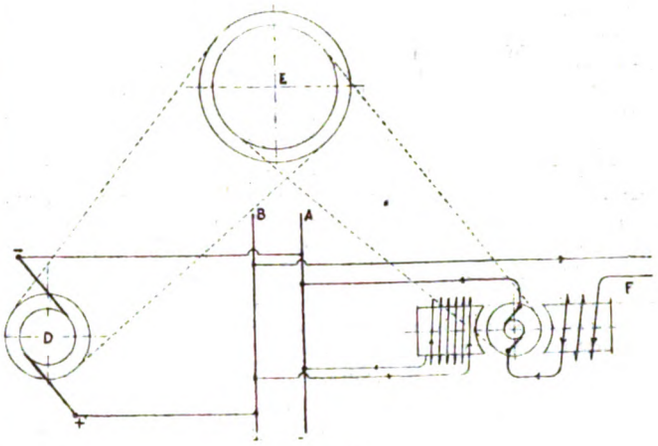

FIG. 1.

distant end. As the current in the feeder increases the series coil comes into play, and more or less neutralising the fine coil lessens the motor action, decreasing the back E.M.F. till at last the two coils balance one another, at which point the resistance of the feeder is just sufficient to reduce the difference of potential at the distant end to the standard value. When the current increases still more the series coils overpower the shunt coils, and the machine then works as a dynamo. Fig. 2 shows

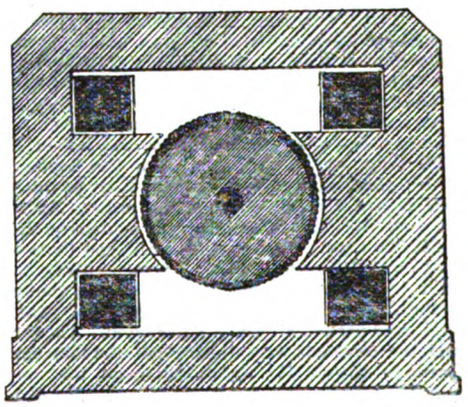

FIG. 2.

the regulating dynamo used by Herr Lahmeyer. As will be seen, it is of the "ironclad" type, the two coils being wound together, not one on each leg as in Fig. 1. The magnets are of cast iron for the sake of economy. The arrangement is said to have been found quite satisfactory at Rostock, where it has been carried into practice.

THE BOARD OF TRADE INQUIRY ON THE LONDON ELECTRIC LIGHTING PROVISIONAL ORDERS.

This Inquiry has been continued at the Westminster Town Hall since our last report. The following gentlemen represented the various parties concerned :—

Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham appeared for the London Electric Supply Corporation; Mr. C. A. Cripps for the Metropolitan Electric Supply Company; Mr. Moulton, Q.C., and Mr. R. S. Wright for the Chelsea Electricity Supply Company; Mr. Muirhead for the St. James's and Pall Mall Electric Light Company; Mr. Roger W. Wallace for the Notting Hill Electric Light Company, for the Kensington and Knightsbridge Electric Lighting Company, and for the Westminster Electric

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Supply Corporation ; Mr. Moulton, Q.C., and Dr. Hunter, M.P., for the Electrical Power Storage Company ; Mr. G. Prior Goldney (the City Remembrancer) for the City of London ; Mr. T. Percy Gunyon (engineer) and two members of the Council for the London County Council ; Mr. C. A. Cripps and Mr. F. M. Jenkins for the Strand District Board of Works ; Mr. Hopwood (solicitor) for the Holborn District Board of Works ; Mr. E. Bayley (clerk) and Mr. G. W. Thompson (surveyor) for the St. Olave's District Board of Works ; Mr. James Spencer for the Greenwich District Board of Works ; Mr. J. H. Horton for the Paddington Vestry ; Mr. Hitchins for the St. George's (Hanover-square) Vestry ; Mr. Wilkins (clerk) and Mr. W. Jenkins (chairman of the Lighting Committee) for the St. James's (Westminster) Vestry ; Mr. Webster Murnane (clerk) for the St. Martin's-in-the-Fields Vestry ; Mr. T. Eccleston Gibb (clerk), and Prof. Robinson, C.E., for the St. Pancras Vestry ; Mr. Cripps and Mr. Greenwell for the Marylebone Vestry ; Mr. H. J. Smith (clerk) for the Lambeth Vestry ; Mr. Harrison (solicitor) for the Bermondsey Vestry ; Mr. E. Moore (solicitor) for the Great Eastern Railway Company ; Messrs. Payne, Son and Pollock (solicitors) for the North London Railway Company.

TUESDAY, APRIL 16.

Major C. E. WEBBER, recalled, examined by Mr. GORDON, said : With reference to previous evidence that had been given as to the laying of mains, what had been meant, he presumed, was that having first, for the minor wants of the street, drawn in one cable, they did not reopen the streets for every 1,000 lamps that were ordered, but simply went to a testing box, put in a main, and drew it through by means of cords. Unless a pipe of inordinate dimensions were first laid down it was attempting what was almost practically impossible except by the system by which each cable had its own separate way. With a number of mains in one conduit it was extremely difficult to draw in additional ones alongside those already in without causing abrasion, or in fact arriving at a complete stoppage by one clinging to the other ; and it was impossible to draw one out of a group of three or four for repair. It would be necessary to draw out the whole mass of cables, which was the Post Office system, but would be out of the question with electric lighting. With reference to the Chelsea Company, they would not have resorted to overhead wires with their uncertain tenure, and, therefore, if they had been unable to get the capital to put down their underground system, they would practically have been obliged to abandon their order.

Cross-examined by Mr. LOYD : When the 1882 Act was passed witness had no measure of the view the financial public would take of clause 27. The Chelsea Company was registered in 1884. According to its prospectus an extension of the time of the 1882 Act was contemplated. In 1884 there was a Committee of Management which included Lord Thurlow, Lord Sudeley, Sir Villiers Lister, Mr. Cunningham, the witness, and one or two others. As to the transformer companies, in his eyes they were offenders ; they wished to rove about the Metropolis and pick out the cream. In 1886 they got their Provisional Order confirmed. That required that there was to be £100,000 appropriated within a year by special resolution, and £2,000 to be deposited or secured within a year in respect to streets in the schedule. It was possible that they had informed the vestry when they got their consent to the Provisional Order that they thought there was no use in trying to raise capital while the 1882 Act remained unaltered. The Cadogan Company threatened competition in 1887. In the autumn of 1887 there were negotiations with the London Company to supply them with electricity. In June, 1888, they promised the vestry to raise £32,000 in five weeks or abandon the order. At that date they had not begun work, but they were extremely anxious to show their *bonâ fides*. Of the £32,000 contracts absorbed £25,313, and there was the building contract of £7,000. The public took up between £10,000 and £11,000. Payments could be made in shares in respect of the contracts. The 13 stations with the 26,000 lights would be sufficient for lighting Belgravia and Chelsea and their portion of South Kensington. The three companies who had made the contracts were to have half the founders' shares. He was not prepared to dispute Mr. King's statement that on the Chelsea system it required £132 500 for batteries alone for 100,000 lights. £108,000 would be required ultimately when they had got the full plant at work, so that the capital of the Chelsea Company would be increased before long to £200,000.

Cross-examined by Mr. C. A. CRIPPS : He had attacked the system proposed by Mr. Gordon for laying down the distributing mains of the Metropolitan Company ; they could adopt, if necessary, precisely the same system as that witness was now proposing. As to three contractors representing the £23,000 out of the £32,000 having the control of the company—if put in that way—it went into the hands of three shareholders who had a majority of votes. There might be great controlling shareholders in the Metropolitan too. Putting aside the contractors witness's company had twenty or thirty shareholders as nearly as he could recollect, but it was a small company, and it was a relative question to the 700 of the Metropolitan. They were not bound down on the question of patents, but were absolutely free.

Cross-examined by Mr. SHIRESS WILL : He was not prepared to tell what motor they were going to use ; it would be decided by Mr. Raworth.

Cross-examined by Mr. HITCHINS : One of the grounds on which the Vestry of St. George's, Hanover-square, had refused to give their consent was that the company proposed to select only the best part of the parish, and that there were three companies willing to undertake the whole parish, They understood that the Metropolitan were applying for the Pimlico part. The Belgrave district was a very scattered one, and the houses were empty for half the year, and it contained few shops.

Cross-examined by Mr. HEWITT : One of the concrete tubes had been taken up in order to see if a 12½ ton steam roller had damaged it, and it was found to be unbroken.

Re-examined by Mr. MOULTON : Two unsuccessful attempts were made to get capital before the Act of 1888 ; after the more favourable terms then given no difficulty whatever was found. Supposing they got these orders they were in a position to carry them out promptly. If the vestry desired a less time than three years they were willing to agree to it. There were very conflicting opinions as to residential quarter being as favourable a ground for electric lighting as shops. Bond-street and Regent-street shops would be more favourable, while Brompton-road shops would be doubtful. This applied to the houses in Belgravia. They would be willing to take the terms of the Metropolitan and the London Company in lieu, but his company's terms were more favourable to the customer.

Mr. MOULTON, Q.C., who appeared on behalf of the Electrical Power Storage Company, said he did not want in any way to go over the ground of the various systems. He was going to confine himself solely to the question of area and opposition with regard to the Electrical Power Storage Company. The company for which he was appearing applied for two areas, one the parish of Paddington and the other a district composed of St. Martin's-in-the-Fields and the Strand. They proposed to take the whole of Paddington, and the system to be adopted is the direct system—that is, direct supply supplemented by batteries, or batteries supplemented by direct supply, according as it is found most convenient. They propose practically to put down mains in every single street in the area, and the time they have limited themselves to is three years, but they would be perfectly prepared to lessen that time.

With regard to the financial position of the company, they proposed to spend something like £30,000 at once in dealing with that compulsory area. Actually devoting your money to works which are of use locally shows that there is a genuine intention to carry out the order. As to the opposition the vestry do not give their consent. The vestry wrote to their company saying they would give the preference to a company that lit Paddington from a station within Paddington. His company fulfilled that requirement, but since then the vestry for some reason or other seem inclined to oppose it and withhold their consent, and it is suggested they desire to do the lighting themselves, but he did not think there was any evidence of their intention to do so. He thought that under the circumstances of his company being prepared to do the work at once promptly and to spread it through Paddington as fast as the demand arose, he should think that nothing could be better for the district than that immediate power should be granted to them, and that the opposition of the vestry ought not to influence the Board of Trade. The Metropolitan Company is the other opposition, and they do not object if they have concurrent powers. He was not going to argue in this speech the relative advantages of competition and districting. His company had applied for a modest area, their terms were better than those proposed by the Metropolitan Company, and he offered a far greater security for doing the work well than the opposing company offered. With reference to the other area—St. Martin's-in-the-Fields and the Strand—the vestry consent. The vestry do not oppose any company coming in, and the question is simply one of districting or competition. The Duke of Bedford opposes, and wants Covent-garden left out of the area. He (Mr. Moulton) did not think if the area was granted any portion of it should be excepted, but that was of course a question for the Board of Trade. He thought that in the district of the Strand, the centre of theatres and places of amusement, the system proposed by his company would be a very weighty recommendation. It would be a most disastrous thing if the lights in a theatre were extinguished, and he should doubt if, under any system than theirs, nothing could occur that would lead to instantaneous extinction, and he would press upon the Inspector very strongly that the direct system with batteries would alone satisfy the requirements of the public supply in a district so peculiarly situated as the Strand.

Mr. JOHN IRVING COURTENAY, examined by Mr. HUNTER, said he was the managing director of the Electrical Power Storage Company, which had 500 shareholders. For the Paddington and St. Martin's orders several of the large shareholders of his company, including Sir Daniel Cooper, Mr. John S. Sellon, and Mr. J. W. Barclay, M.P., and other friends, had agreed to furnish the sum of £60,000 as a minimum amount, £30,000 to be allocated to Paddington and £30,000 to St. Martin's and the Strand. The gas company supply gas at present to 14,864 houses in Paddington, and the number of lights is 112,770.

Cross-examined by Mr. PEMBER : The capital of the company is £200,000, of which £149,000 odd is paid up. He did not think the demand for light in Paddington would be so great as some people thought. There was a large population. He thought the shopkeepers would want the electric light, but he could not say if there would be room for two companies.

Cross-examined by Mr. HORTIN : The area they had taken in Paddington was, he hoped, the best. He knew of a most suitable place for a station along the Canal, but he must be excused from mentioning it. He did not approve of the kind of competition proposed. He was aware the parish of Paddington had been considering the question of doing the electric lighting themselves, but he was not aware they were contemplating doing it. He thought £30,000 was sufficient to carry out the proposed compulsory work at first. He would be surprised to hear that the Westbourne part alone would take four or five times that amount.

Mr. FRANK KING, recalled, examined by Mr. HUNTER, said that in his order in that part under Schedule A he was bound to put down mains ; and although no requisition might be made in that part under Schedule B, they were bound to supply under requisition. In the first instance he would lay down plant sufficient for 10,000 10-candle lamps, for which £30,000 would, he thought, be amply sufficient. The £2. 8s. per running lamp estimated expenditure under his system would be at the most economical limit, and he had allowed a margin leaving it at £3 per lamp.

Mr. RUSSELL GRIFFITHS, in addressing the Inspector on behalf of the Commissioners of Sewers for the City of London in opposition to the London Company and the Metropolitan Company, gave the history of the Commissioners of Sewers in relation to the lighting of the City of London and said he proposed as little as he could to contrast the relative advan

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tages of the two styles of creating and supplying electric light which had been detailed by so many witnesses. He was quite content to take what his friend Mr. Moulton had said with regard to the difficulties the alternating system would have to deal with. He submitted that the 10,000 horse-power proposed was an entirely unsafe power, and the way in which the supply was to be brought into London from the Deptford Beckton, as it had been called, was a source of danger; there was no reserve of power, and it would be quite unsafe for the City of London to depend on a supply so exposed to damage either by accident or design in the way it was brought in. The jointing also he thought was particularly liable to get out of order. There had been evidence that transformers did not always do their work, and it might be possible for the high voltage in the mains to get into a house. They had heard of the accident to the Pittsburg gentleman arising from a voltage of 1,000; therefore, if anything did happen to the transformer that it did not do its duty there would be great danger to the inhabitants of a house. Another thing about the alternating system was the fact that no motor had yet been discovered for it. On the question of competition in the City he thought it would be highly inconvenient, not to say impossible. He thought there would be no hardship entailed upon the citizens of London or upon the respective undertakers if they did not get their Provisional Orders this year, because practically the citizens would be safe in the hands of the Commissioners of Sewers, who were really trying to do the best they could for the constant future electric lighting of the City, and the Provisional Orders, however beneficial they might be to the companies who have promoted them, are not beneficial to the public at large. After he had called his evidence he should ask the Inspector to say in his report to the Board of Trade that there were special reasons for not including in the Provisional Orders the area of the City of London. He could assure the Inspector that the Commissioners did not desire in any way to stop the extension of electric lighting, that they really wished to foster it with a paternal hand, but they did not want such conditions imposed upon them as were proposed by these particular orders.

In the course of Mr. Russell Griffiths' speech the Earl of Crawford and Balcarres was called to clear up one or two points on the capital of his company, the estimated number of lights, and the cost of laying distributing mains.

WEDNESDAY, APRIL 17.

Mr. HENRY BLAKE, examined by Mr. RUSSELL GRIFFITHS, said that he was the principal clerk to the Commissioners of Sewers. The Commissioners of Sewers had spent £12,519 upon electric lighting during six years. Under the contract made with the Edison Company, which was to have commenced on the 1st February, 1882, it was arranged to use certain subways in the Holborn-viaduct. Later there were negotiations for a contract with the Brush Company. As to the lighting of the City in the past, in 1823 the price of gas was 15s. per thousand; in 1849 it had fallen to 5s. and to 4s. There was no map in existence now showing all the sewers and pipes under the City streets. The 1885 map contained all that were known. The Hydraulic Power Company had since put down pipes. In the Edison contract the City would not interfere with the company supplying private lights. So far as the witness knew the City was in effect practically treated in the same way with regard to gas lighting that other parts of the metropolis were.

Cross-examined by Mr. PEMBER, the witness said he could not point to anything in the Electric Lighting Acts of 1882 or 1888 which excepted the City of London from the general operation of the Act.

Mr. PEMBER said that he should argue when his time came that with regard to the Electric Lighting Acts the City was as much open as a district over which a Provisional Order can be given as any other part of Great Britain.

Cross-examination continued: The principal duty the Commissioners kept before them was the matter of street lighting, being also desirous of giving the citizens the benefit of the new light under guarded conditions. As to their conditions being in conflict with the Electric Lighting Acts of 1882 and 1888, witness did not think they were. He did not think that Clause 29 was in conflict with the spirit of those Acts. Clause 36, as to the reduction of price after a 10 per cent. dividend, was no doubt to some extent framed upon an analogy to the sliding scale in the Gas Acts.

WITNESS continued that he was not aware of a clause of that class being rejected by the 1886 Committee. No doubt the power to purchase in 42 years constituted a very material difference in the position from that of a gas company which had got its works for ever. As to the duration of the public lighting contract for 21 years, he did not think that interfered with the provisions for private lighting. As to the Commission having at the end of 21 years the option to renew the public lighting contract for a further seven years, the companies were not obliged to enter into this contract.

No, but they are obliged to tender under this specification?—Yes. As to the event of the contract having involved a loss to the contractor, and his being forced to renew it for seven years, witness thought he might trust a body like the Commissioners.

Now will you let me read Clause 40 to you:—"Power is to be reserved to the Commissioners to acquire the undertaking and works by purchase at the end of 21 years."—Well, if the company choose to contract themselves out of the Act.

Now we have got it that you do, on behalf of the City, claim in this specification power to divide the whole of the Electric Lighting Act by two?—We seek to get the contract on these terms. The power to determine the contract in the case of failure, the witness continued, was to guard against failure.

Mr. PEMBER then put the case of bad feeling arising between the company and the Commissioners; in a fit of anger the Commissioners, the learned counsel said, might immediately order the removal of all the mains and conductors.

Mr. RUSSELL GRIFFITHS: That is all right.

Mr. PEMBER said he would rather put his faith in writing than trust to the temper of a public body or an individual.

The WITNESS: You know there are 95 Commissioners.

Mr. PEMBER knew that, but there was only one engineer, and there were generally one or two belligerent spirits. However, that was the effect of the clause.

WITNESS continued that under Article 39 all the districts might go into one hand, but there were only two or three companies apparently capable of doing that. The engineer had reported to the Commissioners on these orders. Mr. Preece had advised the Commissioners, and he had been very instrumental in arranging the specifications.

Re-examined by Mr. RUSSELL GRIFFITHS: These specifications were for private contracts with the Commissioners, and did not pretend to be under the Act.

Mr. WILLIAM HENRY PREECE, examined by Mr. RUSSELL GRIFFITHS, said he was the electrician to the General Post Office. He had advised the Commissioners of Sewers since 1882. There were 24,983 inhabited houses in the City, the residential number of persons being 261,061; during the day the population would be something over a million. He estimated the present number of gas lamps in houses throughout the City at 622,000 for ordinary private purposes. The public lamps were 3,136, and were lighted at a present cost to the Commissioners of £10,530 per annum. The light was required for private purposes up to about seven o'clock, but there were the printing offices, where it was required all night. It was, of course, extremely difficult to form any accurate estimate of the number of hours of lighting a place like the City, and the only illustration he could get to draw a conclusion from was the central station of New York—the Edison Company's, in the neighbourhood of Wall-street, somewhat similar to the district of the City, and when he was in America in 1884 he took a good deal of pains to arrive at a fair conclusion as to the average number of hours per lamp to-day, and it came out at 2¼—2·4 hours per day: that would be 876 hours per annum for City purposes, offices, restaurants, &c., for private lighting. The latitude of New York was 41, and of London 52, which would make a difference in the daily average of artificial lighting of an hour, which gave 3·5 for London. He doubted whether it was fair to draw any comparison whatever between the private lighting of residential districts like Kensington and Wimbledon and the City. Mr. Crompton put the apex of the curve of light at Kensington at a little after seven o'clock, and the principal demand from five to seven in winter.

Would it be possible, do you think, if a company supplied largely the residential part and the shops and the theatres in the West End that they could also in the four winter months, say, supply the City at the same time?—Witness thought they would overlap very much, and the consequence would be that if they started with too small a plant for the ratio of the demand in the City their supply would rather diminish. With additional machinery standing idle the effect of its running light would be very uneconomical. The public lamps in the City were spread over 46 miles, which gave for a double main 92 miles, and if there were two competing companies 184 miles. There were 13 miles of main streets, 6½ miles of second class streets, and 13¼ of third class streets, and of courts and alleys about 12¼ miles. To replace the existing gas lamps witness estimated that it would require about 500 arc lamps of 500 watts and about 1,000 glow lamps of 25 or 32 candle-power. The number of hours the public gas lamps were lighted in the City averaged 4,300 hours per annum. As to the number of lamps that would probably be required for private lighting in the City, witness thought it might fairly be assumed that in the competition that must take place between electricity and gas, of the 622,000 gas lamps he had mentioned they would probably get one-third, say, 210,000 for glow lamps. That would be about 70,000 for each of the three districts of the specification map. The Post Office installation was put up under the superintendence of the witness, and there the cost of lighting per unit—that was the unit they had in the Electric Lighting Act—was 3½d. They used Willans and Robinson's engines, old type—not so economical as those of the present day, which, if introduced, he thought, would reduce the price per unit to 2½d. The price mentioned was simply cost of production—nothing for interest on capital. He quite approved of the City specifications. He thought the Deptford proposal a gigantic experiment.

As an electrician, will you tell us the grounds on which you form that opinion?—Yes. Generally I may say this—that I am a decided advocate for the distribution of electricity over extended areas by means of alternate currents and the transformer system, and I consider the question of concentrating all your eggs in one basket, as the London Electric Supply Company have at Deptford, or distributing your central stations over the metropolis, as other companies propose to do, is simply a commercial question—a question of pounds, shillings and pence. There has been ample evidence given here of reasons *pro* and *con*, and if a balance-sheet were struck between those reasons I think myself that it would be found that they balance each other very fairly. But my objection, the strong objection that I feel to the scheme of the London Electric Supply Corporation, is not a question of their central station—for I believe that has been perfectly worked out—but it is the connection between Deptford and London by means of their mains. The question does not seem to me to have been at all solved by Mr. Ferranti, and I regard the proposals that have been submitted to this tribunal as regards the mains as very objectionable indeed. I think the form of main proposed by the London Electric Supply Corporation is not in consonance at all with the rest of their scheme, and it is a very weak point, and one that will require further and more mature consideration. He anticipated great difficulties—difficulties of insulation, of joints, and of disturbance to contiguous telephones and telegraphs. He had not seen any motor to which could be applied all the energy produced by the alternating system. There were two or three spoken of as existing; there was the Tesla, but

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it was not on the market yet. There were direct system motors on the market. There would doubtless be a large demand for motive power in the City. As to the subdivision of the City into three districts, the main reason which had guided the Commissioners of Sewers, and that certainly guided witness in recommending it, were to give the public the benefit of competition, at the same time avoiding the cutting up of streets by rival companies. Holborn, Newgate-street, Cheapside, Fleet-street, were now almost choked by pipes. The Post Office had from 15 to 20 down Cheapside, and he did not think it would be possible to lay a new 6-inch main down Cheapside; in fact, they had been compelled to go along some of the bye streets. Two companies in one district would sooner or later amalgamate. With the City divided into three districts the fear of competition would maintain a good service. As to the model of the mains shown by the London Company, there was no counting on the outer sheath of copper; it was admitted, he thought, by Lord Crawford and Mr. Ferranti that they proposed to insulate the outside conductor, and that the question of insulation was simply one dependent upon some mutual arrangement between the company and himself. With regard to insulation and leakage, as far as danger to persons was concerned, he thought there could be no more effective mode than that suggested by Mr. Ferranti. If the outside conductor were buried in earth or in contact with earth he did not think there would be danger of shocks to persons, but the telegraphs would suffer. His opinion was that with the outside to earth all the telephones in London would be affected with 10,000 volts. As to the maximum price proposed in these orders, 8d. per unit, they were in a regular wave of progress tending towards economy; during recent years the cost of dynamos had been diminished by at least one-third, the output of the dynamos themselves had been increased at least three times, so in that one item alone we were now nine times better off than off five years ago. He did not anticipate that there would be the same advance in the future, but an advance probably.

Cross-examined by Mr. PEMBER: The electrostatic induction from the cable between Deptford and London depended upon there being a curve between those two places; if they could get an absolutely straight line it would not be set up, but earth conduction would. He was not aware that an experimental main insulated for the express purpose of meeting the conjoint objection as to the safety of the public and the burying of the uninsulated main in the earth was being laid. He had no doubt whatever that a cable could be made which would get rid of the Post Office objection. When that was done his objection to the Deptford scheme vanished. He had certainly not any doubt that a motor could be found which could be adapted to alternating currents. With those two points excepted he had nothing to say against the scientific aspect of the scheme, leaving out the question that the Board of Trade undertook safety to life, and, as far as the Post Office was concerned, safety to telegraphs. As to the statistical part of his evidence, the 622,000 gas lights in the City were arrived at in this way—a certain number of houses were taken and the number of lamps counted, and it came out that the average number of burners per house was 25, and multiplying the number of houses by 25 brought out something over 600,000. Then the quantity of gas consumed supplied to the City for private lighting purposes by the Gas Light and Coke Company was taken and divided by the average consumption per burner, and the two together were found to bring out that figure very nearly, so that the 622,000 was taken as a mean. As to the benefit of competition to the public, that would be secured by the three-district principle, from there being a marauding individual close by ready to pounce upon other preserves if the service there were not properly rendered.

There is just one other point. I do not think I need really discuss it with you, because Parliament has already discussed that, but, if you were acting as consulting engineer to an electrical company like the London Electric Supply Corporation, would you advise them to tender on the basis of being ousted in 21 years and having all their undertaking bought up?—Yes. Mark you, it is a purchase by agreement. It is not a compulsory sale.

Let us have a look at that. Provided it was by agreement with arbitration you would not mind?—No.

You would not advise them to submit to the purchase clause in these specifications, as contained in clause 40, I believe: "Power is to be secured to the Commission to acquire the undertaking and works by purchase at the end of the twenty-one years, or each succeeding seven years, on giving six months' notice in accordance with section 2 of the Electric Lighting Act, 1888." That is not agreement you know?—I do not know what section 2 of the Electric Lighting Act of 1888 is.

Just look and see whether you would like that.—After referring to the section: I was not responsible for that clause.

Re-examined by Mr. RUSSELL GRIFFITHS: With Mr. Ferranti's precautions the dangers to the individual from the Deptford main would be reduced to a minimum, which would not increase the difficulties of the insulation against disturbance to telephone and telegraph wires.

Examined by Major CARDEW: With reference to this question of interference with telephones, is not it the case that, assuming the proposed main to be earthed at Deptford, and also, say, to be earthed at the distant end, the inequality in the currents in the two conductors thus produced would cause an interference with telephones from current induction?—Yes.

In addition to that there would be a certain interference with telephones from electrostatic induction, which is a different thing?—Yes.

But if the earth can be kept to the generating point, there is no reason why there should be any current inductive effect?—As long as the insulation is perfect.

Mr. RUSSELL GRIFFITHS said that this closed the evidence on the part of the City of London.

Mr. SHIRESS WILL, Q.C., M.P., in opening the case for the House-to-House Supply Company, said that the company was located at South Kensington, having a station at Lillie Bridge on a site between the railway and the Brompton Cemetery. There were at present three engines there, each set of plant being capable of supplying 4,000 incandescent lamps, and completed stations would contain twelve such sets. They were tied to no system, but had commenced with the high-tension alternating-current converter system. He advocated districting. The whole difficulty in this country up to now in the way of house-to-house lighting had been not a scientific one: the commercial difficulty had been entirely the cost of the mains, due to the battery system and the low-tension system, of course. That was to say, in order to carry a current of low tension of 100 volts you would require a main of 400 times the size of the one to carry 2,000 volts. The disadvantages of the plan of Mr. Moulton's company were the rent, &c., of the thirteen stations, and of Mr. Crompton's the loss from the use of accumulators. The system proposed by the House-to-House Company was in use at Brighton and Eastbourne. He did not think that the motor question affected the Kensington area beyond being a small matter. He said that small compact companies located in the particular district assigned to them would be the best safeguard for efficient lighting.

Mr. ROBERT HAMMOND, examined by Mr. SHIRESS WILL, said that he was the managing director of the House-to-House Company, chairman of the Brighton and Hove Electric Lighting Company, and managing director of the Eastbourne Lighting Company. The nominal capital of the House-to-House Company was £350,000, of which £41,600 had been subscribed. He thought that the standard price should be fixed at the expiry of the first seven years, based on a 10 per cent. dividend.

Cross-examined by Mr. WALLACE: The 6½d. cost of production per Board of Trade unit at Brighton was high on account of the smallness of the works. What do you anticipate you will be able to charge for electricity? What do you propose to charge under your order for the current?—We propose to charge a sliding scale, which I hope some day will be universally adopted. We make a sliding scale depending upon the number of hours a man uses his lights. We ask him to fix his maximum supply demand, and we do all we can to encourage the continuous use of that number of lights, whether it be 10 or 100. We charge upon the sliding scale upon this basis, that for the first 100 hours per quarter of his maximum supply demand we charge 1s.; the second 100 hours 8d., and all beyond 4d., so that if he is a man who uses it five hours per night he gets it very cheap indeed. Witness continued that the customer fixed his maximum number of lights and a converter was put in accordingly.

Mr. WILLIAM LOWRIE, examined by Mr. SHIRESS WILL, said that he was engineer to the House-to-House Company. At Eastbourne the voltage was 1,900, at Kensington 2,000. At Eastbourne they had always succeeded in keeping a high state of insulation. At present they supplied 500 lights in Kensington, the Parker-Lowrie dynamo being used; the unit of horse-power fixed there was 200.

Cross-examined by Mr. MOULTON: In practice it would be difficult to say whether it would be exactly true that direct mains would be 400 times the size of high-tension mains.

Major MARINDIN: He said theoretically. Under similar conditions it is right.

Prof. FORBES was recalled as to tests he had made at the West Brompton station under very severe conditions, and he found the parallel working there succeeded in a way that was absolutely unexceptionable in regard to switching on a dynamo: there was not the slightest flicker.

THURSDAY, APRIL 18.

Prof. WILLIAM CROOKES, Chairman of the Notting Hill Electric Lighting Company, examined by Mr. WALLACE, said his house had been lighted by a private installation for the last seven or eight years, and friends of his had united together to form a small company to try to introduce the light into the neighbourhood. Up to the present time they had only raised a small amount of capital for the purpose of the preliminary expenses of the concern, and they had not made any effort to get the money from the public or do anything more than arrange to find the necessary capital as soon as it shall be required. The nominal capital of his company was £100,000. He considered it was a private company, not got up with any particular object of making profit but simply to introduce the light. They had not actually bought the sites at the present moment, but they had two and probably three sites in a very good position, which their consulting engineer had seen, and they were in treaty for them. His company were before the Vestry of St. Mary Abbotts, Kensington, with other companies for about twelve months. Speaking of the Notting Hill Company the vestry reported:—"This company has not yet called up any capital or constructed any works, but your committee are satisfied that it is a *bonâ fide* concern, well supported both by engineering talent and by gentlemen of local influence, and believe that if a Provisional Order is granted the company will at once apply itself to carrying out works in the district assigned to it."

In answer to the INSPECTOR the WITNESS stated that the directors had each taken 15 shares of £10 each, which was sufficient to carry on the expenses. There were Articles of Association, and everything had been done in the regular way.

Mr. WALLACE then addressed the Inspector on behalf of the Kensington Court and Kensington and Knightsbridge Electric Light Companies. He said that the Kensington and Knightsbridge Company is one that has been in existence for about a year and a-half, having bought the undertaking of the Kensington Court Electric Light Company. The two companies now ask practically for the same order. The Kensington Court Company were in possession of the licenses granted by the Board of Trade, and the Kensington and Knightsbridge Company, taking over the Kensington Court Company, thought it advisable to apply to the Board of Trade in the name of both companies in case there should be any technical difficulties arise as to the transfer of property from one company to another. There are two stations in that area, one situated at Kensington

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Court, on the property lately belonging to Baron Grant, and the other situated in Chapel-street, on the north side of the Brompton-road, the whole area being one square mile. He asked for a small portion of the Chelsea Company's district, a small piece from the House-to-House Company, and a small portion up in the corner near Wright's-lane, down which his company had already laid their mains. These were the only alterations he asked the Inspector to make in the boundaries as allocated by the vestry. He did not wish in any way any further than he could help to go over the ground that had been traversed so frequently during the course of the inquiry by other promoters, but he thought there was a slight difference between the policy advocated by the Kensington and Knightsbridge Company and the policy advocated by the promoters of the other schemes. He thought he might divide the principles proposed by the promoters of these various undertakings into three: There were those who desire to have concurrent powers over the same area, there were those who believe in districting it, and there were those who thought that the promoters of the different undertakings and the capital of the undertakings should be as far as possible within the district itself, and that the stations should be situated close to the area of supply—that the local people in the district, the consumers themselves, should find the capital necessary to carry on the works from which they obtain their current, and that the district should be lighted from stations in the immediate vicinity. With regard to concurrent powers, he thought it necessary to mention that in his district they had streets very similar to the streets that have been spoken of by the local authorities for the Strand. High-street, Kensington, was a very narrow thoroughfare, and the traffic was in fact congested to a very great extent—there was the same class of mains there that is found in the Strand, not only gas and water mains but telephone and telegraph mains. As far as the mains of his company were concerned it would be a serious thing for them if the mains of competing companies were allowed to come down their conduit, because their mains were not insulated at all. Up to the present his company had not made any arrangements for having a military man upon its directorate, but the other companies had already provided themselves with generals in order to take part in their battles. As to what the result of competition would be, he thought Mr. Moulton had put before the Inspector much better than he (Mr. Wallace) could. It would not manifestly do to allow those companies which are advocates of districting to be interfered with by an outside company such as the Metropolitan, which would, according to its proposals, interfere with the Kensington and Knightsbridge portion of the Knightsbridge district. In so doing there would not be a fair test, and nobody would be able to judge hereafter in the event of the failure of either company what the cause of that failure was; and he would suggest that the Board of Trade should allow all those companies that have proposed to light an area by themselves to have that district, and that it could then be seen what they were able to do without competition. With regard to the work that has been done, the building has been erected and the boilers put in, and in about a month's time electricity will be supplied from the Knightsbridge station. At the Kensington Court station they had been at work for the last three years. They had Babcock's boiler, Willans' engines, and Crompton's dynamos and batteries, the batteries being used only for the purpose of giving a limited supply of electricity in case of the breakdown of the engines. With this system you can stop the works, properly examine the engines, and in the case of anything going wrong with your boiler or anything of that kind, you can rely on your batteries while such temporary work and alteration is being made. With regard to the smoke nuisance he thought his company had got over that difficulty by using Welsh coal and keeping the exhaust steam separate from the smoke. As to vibration, they used the Willans engine, and if the Inspector visited the works he (Mr. Wallace) thought it would be seen that no nuisance was likely to arise on that score. In conclusion, Mr. Wallace having enumerated the places now lighted by his company, said that from the commencement of their endeavour to meet the public wants, now three years ago, they had not had any failure in the light except on one occasion, and that was when a machine broke down, and he thought that was a record that no other company appearing before the Inspector at present could furnish.

Mr. ROBERT STEUART ERSKINE, examined by Mr. WALLACE, said he was the secretary of the Kensington and Knightsbridge Company. The company was first started in 1886, under the name of the Kensington Court Electric Light Company, with a capital of £10,000, as an experiment one, with the object of working Kensington Court. There has been no public subscription, all the money having been found by the directors and their friends. The present capital is now £37,000, all paid up with the exception of £500. There is a considerable amount more promised—about £75,000—which will be available as required. There are six sets of 180 horse-power engines on order at the present time for delivery in the summer for next winter's work. They had been lighting part of the Town Hall, Kensington, for about a year—the council-room, the board-room, and a few other parts. There was a considerable demand for light in the district, and they had guaranteed to commence supply by the beginning of May under the 1888 license. There has never been any nuisance at either of the two stations that they have not been able to meet at once and within a day or two put right. No dividend had been paid as yet, but they were working at a profit now. At first they made a loss, but last year they turned the corner, finished with a profit, and wiped off the previous losses. They were getting a fair number of houses to light, but the number in a street was so small that it would not pay two companies to lay down mains for them.

Cross-examined by Mr. C. A. CRIPPS, counsel for the Metropolitan Electric Supply Company: The whole amount of the paid-up capital within a small amount had been expended. He could not say what the bank balance actually stood at at present. They never had a big balance at the bank as the amount paid up was immediately spent on plant and mains. He thought they had one distributing main of rather over half an inch sectional area. That was the largest, but most of them were a quarter of an inch—between a quarter and half an inch, and some under the quarter.

Cross-examined by Mr. BRANDRETH: He believed they had included Stanhope-gardens. He was aware that was more than half a mile from the station, but there would be a battery station within a very short distance. He knew the vestry especially wished to have one of the storage systems introduced into the parish.

Re-examined by Mr. WALLACE: The site chosen at Knightsbridge is the only available site that they could find anywhere for their purposes.

Mr. FRANCIS RADFORD, called, examined by Mr. WALLACE, said he was one of the directors of the Notting Hill Electric Lighting Company, and resided in the district. He was a large owner of property in the district, and he and others were the trustees for over 50 houses in Holland-park. He thought there would be no difficulty in getting the necessary capital in the event of their getting the Provisional Order if the other directors were of the same mind as he was. Personally he saw no difficulty about capital.

Mr. ALBERT EDMUND LOUGHBOROUGH, the solicitor and Parliamentary agent, was called and produced the Articles of Association of the Notting Hill Company, and read the names of the subscribers thereto as follow: Sidney Water, 24, Ladbrooke-square, W.; James T. Jarvis, F.R.G.S., 30, Ladbrooke-square, W.; William Crookes, 7, Kensington Park-gardens; Joseph Crookes, 7, Kensington Park-gardens; Alexander Howden, 72, Holland-park; Francis Radford, 26, Pembridge-gardens; and Aston Webb, 13, Lansdowne-crescent, W.

Major MARINDIN: Are there any other shareholders?

The WITNESS: There are no other shareholders.

Mr. WALLACE then addressed the Inspector on the Westminster Company's case. In the course of his speech he said the company have a site already at Victoria-mansions belonging to one of the directors of the company, and they have placed their boilers down there and ordered plant from Messrs. Crompton which, in the course of the next few weeks, would be able to supply about 5,000 lights in the immediate district. The whole available land is about half an acre in extent. It was not proposed to be used as a permanent station, but would afterwards be used as a battery station. In the meantime, as the demand was not very large, they proposed to go on lighting from there at present. The only difficulty the Westminster Company felt was the supplying of Mayfair, which was a considerable distance from either of the stations. They proposed to have a battery station within the area of Mayfair.

After a discussion as to procedure,

Major MARINDIN: Then if there are no objections I should propose taking the vestries in the order in which they come, beginning with the objectors to the London Supply scheme.

Mr. LOYD: If you please, sir.

The following vestries have dropped out as far as the London Company is concerned:—Chelsea, Greenwich District Board of Works, St. George the Martyr, Southwark; Paddington; St. John's, Hampstead; St. Luke's, Middlesex; Rotherhithe; St. Mary, Islington; St. Olave's, and Shoreditch.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To-night) FRIDAY, April 26th.

INSTITUTION OF CIVIL ENGINEERS.

7:30 p.m. Students' Meeting. "Photography for Engineers." By C. H. GALE and V. W. DELVES-BROUGHTON, Students Inst.C.E.

ELECTRO-HARMONIC SOCIETY.

8 p.m. Smoking Concert at the St. James' Hall Restaurant.

TUESDAY, April 30th.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "The Italian Renaissance Painters: Their Associations." By JEAN PAUL RICHTER, Ph.D.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on "Armour for Ships." By Sir NATHANIEL BARNABY, K.C.B. Paper to be read, time permitting, "The Treatment of Steel by Hydraulic Pressure." By W. H. GREENWOOD, M.I.C.E.

SOCIETY OF ARTS.

8 p.m. Foreign and Colonial Section. "The Northern Waterway to Siberia." By Capt. WIGGINS, F.R.G.S.

WEDNESDAY, May 1st.

ROYAL INSTITUTION.

1:30 p.m. Annual Meeting.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Ordinary General Meeting. Inaugural Address by the President, Mr. CHARLES COCHRANE.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. "Secondary Batteries." By W. H. PREECE, F.R.S.

THURSDAY, May 2nd.

ROYAL INSTITUTION.

3 p.m. Afternoon Lecture. "The Science of Animal Locomotion in its Relation to Design in Art (Illustrated by the Zoopraxiscope)." By EADWEARD MUYBRIDGE.

INSTITUTION OF MECHANICAL ENGINEERS.

7:30 p.m. Ordinary General Meeting. "Research Committee on Marine Engine Trials: Report upon Trials of the s.s. 'Meteor.'" By Prof. A. B. W. KENNEDY, F.R.S.

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CONTENTS OF THE CURRENT NUMBER.

Notes 797
A Song After Lamplight 701
The Use of the Integraph in Determining Some Problems in Electro-Dynamics. By L. B. Atkinson. Illustrated ... 702
Müller and Lahmeyer's Distributing System. Illustrated.. 703
The Board of Trade Inquiry on the London Electric Lighting Provisional Orders 703
Meetings of Scientific Societies. 707
This Year's Exhibitions 708
Obituary—
Warren de la Rue, D.C.L., F.R.S., Ph.D..... 709
Letters for Learners and Un-Professional Readers. By H. D. Wilkinson. Illustrated. Continued 710
Macquaire's "Alpha" Arc Lamp. Illustrated..... 711
Economics of Planning and Constructing Electric Light and Power Stations. By Alex. P. Wright. Concluded 712
The Institution of Electrical Engineers—
"Underground Conduits and Electrical Conductors." Ill. 713
Some Electric Lighting Central Stations in Europe, and their Lessons.—Part I. By Prof. George Forbes. Illustrated. Concluded 716
A Method of Detecting Dissolved Chemical Compounds and their Combining Proportions. By G. Gore, LL.D., F.R.S. 626
American Notes 719
Correspondence—
The Education of Electrical Engineers.—Gerald Day... 720
Globular Lightning.—Edwd. W. Cowan 720
Photographs of Lightning.—A. K. C..... 721
Mirrors for Galvanometers.—A. B. Smith 721
Patent Record 721
Books Received..... ... 723
Companies' Meetings, &c.—
The Anglo-Portuguese Telephone Company (Limited) 723
Great Northern Telegraph Company of Copenhagen (Limited) 723
City Notes, &c..... 723
Companies' Share List..... 724

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THIS YEAR'S EXHIBITIONS.

At least two Exhibitions of considerable importance to the electrical world are to be held during the present year, and for some time past their preparations and prospects have been watched with some anxiety. It cannot be denied that misgivings were at first entertained with regard to both of them, the one in the French capital having too much the appearance of a political demonstration, and the other, in Birmingham, seeming too like a feeble attempt at rivalry on purely industrial lines. If the Paris Exhibition did not attract visitors it was hardly likely the English Exhibition would succeed any better; and if, on the other hand, Paris was to be a success, there would be small chance for Birmingham in the same year. So it appeared when these projects were first mooted. But as the preparations have advanced all apprehensions of this kind have gradually disappeared, the most encouraging accounts reaching us from both places with regard to the result of the undertakings. At Birmingham, where the Exhibition, which is to be held in Bingley Hall, will be largely of an electrical character, demands for space are already threatening to exceed the limits assigned to it, although the show will not be opened

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until the month of August. Efforts are being made to secure representative exhibits from all parts of Europe and America; and from what we hear about it there is good reason to expect a collection of electrical appliances such as has never before been brought together in one place. A novel feature of the Birmingham Exhibition will be the working of the whole of the machinery employed in the building by electrical power. Although the Exhibition is to be styled "Electrical and Industrial," electrical interests, both scientific and commercial, are strongly represented on the Committee; and if they are adequately supported a very distinctively Electrical Exhibition will be the outcome.

At the present juncture in the affairs of electrical industry the success of the Birmingham Exhibition is much to be desired, as it cannot fail to exercise considerable influence for good or evil on the electrical engineering trade of this country. We certainly do not fear competition from France, or from perhaps any other Continental nation to be represented at the Paris Exhibition. As regards America, if we do not speak with the same confidence it is rather because of a prevailing prejudice than from any doubts as to the superiority of British manufacture. We have none whatever as regards British science; and if our inventors and makers are keeping pace with it the display at Birmingham ought to set the tide in favour of this country even among visitors from the United States, who, it is expected, will cross in vast numbers. This circumstance is one on which the managers at the Midland capital are to some extent reckoning for the success of their venture. That Exhibition will not open until the one at Paris has got well advanced; and the crowd of travellers who are certain to pay this country a visit on their return journey will, many of them, not neglect to take a peep at what we have to show them at Birmingham. It will be our own fault if we do not profit by the coincidence, instead of suffering by it, as was at first feared.

At the Paris Exhibition we shall hope to hold our own notwithstanding the national jealousies which are never wanting in the French capital, and the extravagant preference which appears to have been shown to rival exhibits from the other side of the Atlantic. Mr. Edison is, of course, very much to the fore as usual on these occasions. All we need say about it to his English competitors is that if they are content, as he would say, with a back seat, they cannot blame him for sitting in front. Many of them, perhaps most, do not believe in the great magician; and did they speak their minds he would not be flattered if within earshot; but somehow it happens that they fail to assert themselves, and allow the likes of him to be taken at his own estimate. It is, perhaps, too late to mend matters now, but not too late to take a lesson for future guidance. One other reason, of a quite different complexion, will probably contribute to the preponderance of American Electrical Exhibits at Paris. For a good while the English manufacturers were shy about taking part in the show, and had to be whipped up with a vigour which would not have been needed at any other time, and which after all has been only partially successful. What the British Government declined to do, naturally British subjects hesitated to do; and the only consolation we have is that we are not singular in this respect, the Americans alone taking the Exhibition seriously or with any show of hearty appreciation.

With, however, the promised influx of numberless sightseers from the States—and perhaps also the retirement of General Boulanger from the scene—the political character of the Exhibition has gradually faded out of sight, and unless rudely reminded of it by the Parisians themselves their foreign visitors may come and go without realising that the fête ostensibly commemorates the taking of the Bastile in 1789. Judging by the preparations now being made for their transport there will also be no lack of English visitors, few of whom have much sympathy with the French Revolution, and many of whom regard it as the greatest calamity of modern times. The Exhibition managers as well as the French Government have, however, discreetly held their tongues about it of late, fearing, perhaps, that a practical repetition of the event by way of centenary would contribute as little to the success of the Exhibition as to the safety and comfort of their guests. It is to be hoped that these wise counsels may prevail, and that nothing will happen to stop the stream of visitors which is preparing to start for the gay capital. Birmingham is pretty sure to profit by the occasion; and both at that place and at Paris English electrical engineers will have opportunities for displaying their skill such as occur but very rarely, and of which we trust they will take every possible advantage.

OBITUARY.

WARREN DE LA RUE, D.C.L., F.R.S., PH.D.

It is with much regret that we have to record the death of Mr. Warren de la Rue, which took place on Good Friday. Mr. de la Rue was a native of Guernsey, where he was born in 1815. He was educated in Paris, and for a considerable period was head of the firm of Thomas de la Rue and Co., in succession of his father, until the year 1880, when he in turn was succeeded by his second son, Mr. T. A. de la Rue. In this business Warren de la Rue turned to good account his great scientific knowledge; but the principal work in which he distinguished himself, and on account of which he has attained a world-wide celebrity, is in the application of photography to the recording of celestial phenomena. The following particulars are taken from *"The Electrician" Directory*, and will be of interest to our readers:—"In 1860 he went to Spain with the Himalaya Expedition, and was successful in obtaining a series of photographs of the total eclipse of the sun on July 18. The results formed the subject of the Bakerian Lecture, delivered to the Royal Society in April, 1862. In conjunction with Prof. Balfour Stewart and Mr. B. Lowry he published 'Researches in Solar Physics,' founded on observations made at the Kew Observatory under his directions. He also took an active part in making the preparations for the photographic observation of the transit of Venus in 1874. He established a private observatory at Cranford, Middlesex, but it was dismantled in 1873, and the instruments presented to the University of Oxford, where they have been employed most successfully by Prof. Pritchard in determining, by means of photography, the distance of 61 Cygni and other fixed stars. In 1874 he fitted up a private physical laboratory, where, employing a battery of 15,000 chloride of silver cells, he has, in conjunction with his friend, Dr. Hugo Müller, carried on an elaborate series of researches on the electrical discharge. The results of the researches have been from time to time communicated to the Royal Society and the Académie des Sciences, Paris. 'The Phenomena of the Electric Discharge' was also made the subject of a most interesting lecture, illustrated by a great number of experiments, at the Royal Institution in 1881. Nearly all the results of Dr. de la Rue's scientific work have been embodied in Papers and Memoirs, which will be found in the *Transactions* of the Royal Astronomical, Chemical, and other learned societies. He acted as juror and reporter in the department of Class XXIX. in the Great Exhibition of 1851, was a juror in Class X. of the Paris Exhibition of 1855, and presided over Section B, Class XXVIII., of the Exhibition of 1862. He was a member of the International Electrical Congress, consisting of all the most eminent physicists of all countries assembled in Paris, and of the jury of the Electrical Exhibition held there in 1881. He was also a member of the Consulting Council of the Electrical Exhibition held at the Crystal Palace, Sydenham, in 1882. He has held office in several societies. He acted for some time as honorary secretary

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of the Royal Astronomical Society, of which he was also president from 1864 to 1866. He was president of the Chemical Society from 1867 to 1869, and again in 1879-88, and was till his death one of its vice-presidents. He was for many years president of the London Institution, from which he retired and became secretary of the Royal Institution in 1878, on the retirement of Mr. Spottiswoode, who was elected president of the Royal Society, but resigned the post in 1882. He was a corresponding mumber of the French Académie des Sciences for the department of astronomy ; also of the Imperial Academy of Sciences, St. Petersburg, the Philomathic Society of Paris, the Royal Society of Upsala, the Society of Agriculture and Commerce, Caen, the Society of Natural Science, Cherbourg, and the Berlin Chemical Society. Three foreign orders have been conferred upon him—Commander of the Legion of Honour, Commander of the Order of St. Maurice and St. Lazare, and Knight of the Order of the Rose, Brazil." Mr. de la Rue died after a short illness from pneumonia. The funeral took place on Tuesday at Kensal-green.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION III.—MAGNETIC FIELDS OF COILS AND SOLENOIDS.

(*Continued from page 658.*)

The question naturally occurring next is, how many rings are we to consider the cylindrical turn or belt of current divided into? Well, first let us divide it into rings of one centimetre width. Now if the solenoid is l centimetres long there will be l such rings, andthe current (C_1) carried by each will be the total current in the cylindrical belt divided by the length l; that is

$$\frac{Cn}{l} = C_1 \text{ in C.-G.-S. units.}$$

This is usually spoken of as the current per unit length of solenoid. We must carry this subdivision of the rings to a still

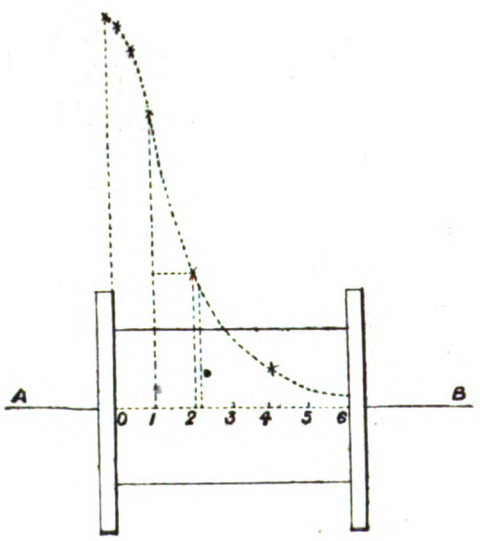

FIG. 148.

greater extent ; but this will be best understood by plotting a curve over the solenoid (Fig. 148) showing the relation between strength of field at the point O produced by different current rings, and the distance of these rings from the point. The axis of the solenoid is along the line A B, and it is at the point O on this axis that we will first set ourselves to determine the strength of field due to the entire solenoid. We might at once take this point at the middle of the coil ; but it is better, as a more preliminary step, to consider the field at one end of the coil first. Any point taken on this axis between the beginning and end of the solenoid will, of course, be the centre of a narrow ring carrying a certain fraction of the current per unit length. It is not necessary to consider now what this fraction may be, for the curve will be of the same shape whatever we take it. In fact, as this fraction of the current would be the same for each narrow ring we take, it may be regarded as constant, and the curve plotted by simply working out the reciprocals of R^3 for a few points on the axis. Raising perpendiculars proportional to the figures so obtained, and joining together the summits of these perpendiculars, we get the outline of the curve as shown. The few points on the axis selected, with corresponding numbers proportional to the field they produce at O, are given below. These few points are quite sufficient to show the general shape of the curve.

Position of ring on axis.	Values of $\frac{1}{R^3}$ proportional to field.
0	·125
$\frac{1}{4}$	·12
$\frac{1}{2}$	·1125
1	·09
2	·0425
4	·011
6	·004

Now, by inspection of the curve it is clear that in any current ring of one centimetre width, that part of it nearer to the point O produces a much stronger field at O than its more remote portion. For instance, in the belt or ring of current between the points 1 and 2 the perpendicular line proportional to the field is much higher at 1 than 2, and if we imagine this ring sub-divided into a very large number of small rings, it is easy to see that the field of each (at the point O) gradually becomes more intense as they are further from 2 and nearer to 1, the increase being in exact proportion to the rise of the curve. In fact, every perpendicular line drawn from the axis between 1 and 2 to meet the curve is proportional to the field produced at O by a narrow ring of current *in the plane of that line ;* and in order to estimate the total field produced by the belt of current between 1 and 2, it is clear that we must add together the values of as many perpendicular lines as can be crowded into that space. But this is the same thing as finding the *area* of the strip included between the two vertical lines at 1 and 2, the curve, and the axis. Now the area of this strip we may consider as made up of two parts—a rectangle and a space like a triangle (shown separated by a dotted line). It would be very easy to find the area of the rectangle, but not so easy to find the area of the triangular space, because one side is curved. But by dividing the space between 1 and 2 into a series of smaller strips the curved side of the triangle in each might be considered straight and the areas found by inspection, adding them together afterwards to get the area of the whole strip. Fortunately we are not obliged to do anything so laborious as that, for by considering any very narrow strip, such as that drawn on the off-side of the figure 2, it will be seen that the little triangle becomes very diminutive, and finally disappears altogether if we take the strip smaller and smaller *without limit*. Just in the same way as the field produced by the belt of current between 1 and 2 is found by measuring the area of the strip contained between these limits, so the total field at the point O due to the whole solenoid is found by calculating the area of the whole curve between the limits O and l. By taking such extremely small strips, then, we may regard them as rectangles of minute breadth, and adding them all together from O to l gives the total area of the curve. It is not necessary to understand the exact process by which this is done so long as the student understands *what* is done and *why* it is done. It will be understood that in adding any series of numbers the process of addition is much simplified if we first separate any factors which are *constant* from those which *vary*. For instance, suppose it is required to sum up all multiples of some number which we will call a, between the limits of $5a$ and $9a$, it is easier to perform the summation by adding the factors which *vary* first ; thus :—$5+6+7+8+9=35$, and then taking the product $35a$, than to add together $5a+6a+7a+8a+9a$. The

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difference in the labour involved in doing it these two ways is at once apparent by taking a as some fractional number, say $1\frac{1}{7}$. In other words $a = 1\frac{1}{7}$ is *constant* throughout, and it is only necessary to sum the factors which *vary* as above, and then multiply their sum by the constant, giving the final summation of the series, viz., $1\frac{1}{7} \times 35 = 40$. Similarly, in the summation of the little rectangles representing the fields produced by each narrow ring of current there are two factors which go to make up the value of each rectangle, one being constant and the other varying with the position of the current ring. The constant factor in this series is the product $2\pi C_1 r^2$, and the factor which varies comprises the reciprocal of R^3 (which varies with the position of each ring), and a fractional quantity which diminishes the width of the current rings (and therefore of the rectangles) down to an infinitesimally small amount. This latter fraction would be a constant quantity were it not for the fact that it is expressed as a fraction of the distance of each ring from the point where the field is to be determined, and this distance of course is different for every ring. We have now only to take the factors which vary and sum up all their possible values between the limits O and l (the length of the solenoid), the result of this summation being equal to

$$\frac{l}{r^2 R},$$

where R has its greatest value, viz., the distance from the point O to the mean depth of the furthest ring (*see* Fig. 149).

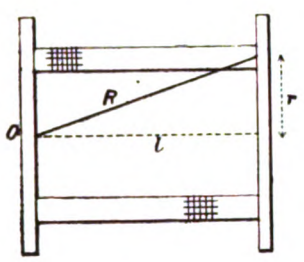

Fig. 149.

The depth of the winding is represented in the figure by the space (partially shaded) between the two bounding lines of the coil, and the line R is from O to a point at the side of the coil central to the winding—in fact, to the point which limits the mean radius r. Multiplying the constant quantity by the sum of the factors which vary, we have the final summation, giving the total field at O due to the entire solenoid, viz. :—

$$2\pi C_1 r^2 \times \frac{l}{r^2 R} \text{ C.-G.-S. units,}$$

which, after cancelling out r^2, becomes

$$2\pi C_1 \times \frac{l}{R} \text{ C.-G.-S. units.}$$

Putting for C_1 its equivalent (Cn divided by l), and cancelling out l, we have for the field at either end of the solenoid

$$\frac{2\pi Cn}{R} \text{ C.-G.-S. units.}$$

(To be continued.)

MAQUAIRE'S "ALPHA" ARC LAMP.

In Maquaire's "Alpha" arc lamp the power necessary for striking the arc and regulating the feed of the carbons is supplied by a small reversing motor. The armature, which is placed vertically between the field magnets, gears by means of a worm on the shaft with a large wheel, the pinion of which drives the upper carbon holder by a rack, so that a revolution of the armature in either direction causes an almost imperceptible motion of the upper carbon in the corresponding direction.

The lower extremity of the armature shaft is pivoted in a movable V-shaped yoke X (Fig. 1), which when the lamp is working is attracted by the field magnets and thus closes the magnetic circuit, at the same time throwing the worm into gear with the wheel. When the lamp is not working the movable yoke is pushed back

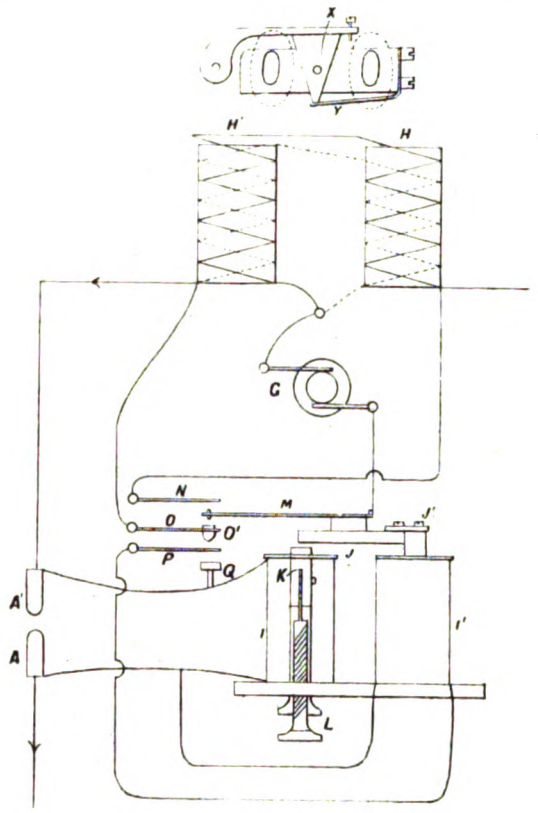

Fig. 1.

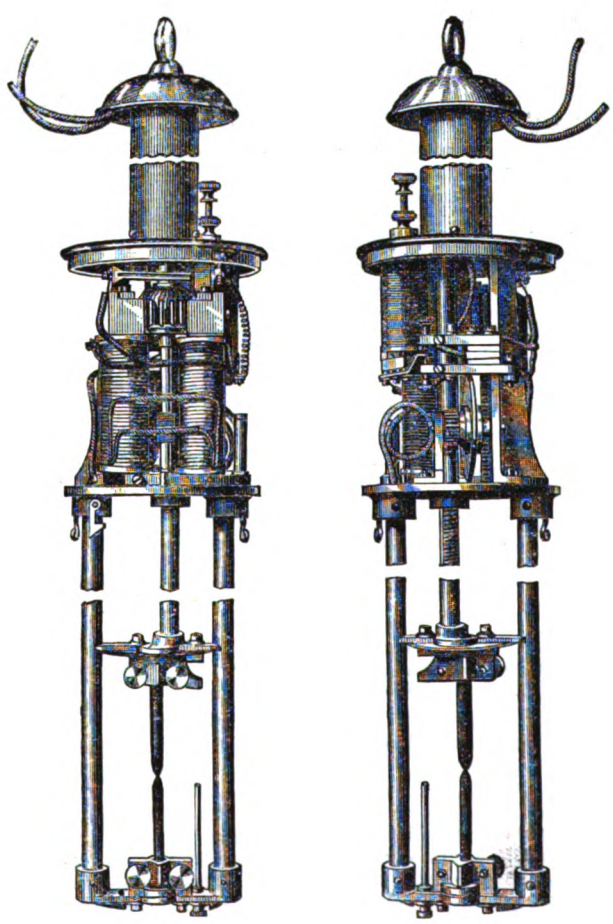

Fig. 2.

Fig. 3.

by a spring Y ; the worm being thus released from the wheel, the rack falls and the carbons A' A come together.

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The field magnet coils H H′ of the motor are in series with the arc, the armature G being coupled as a shunt on the field coils. The direction and duration of the armature current depends on the position between two contact pieces N O of the movable lever M, one end of which is held by a flat spring, J′, the other end being free to move. A portion, J, of the lever, M, is of iron, and is controlled by an electro-magnet, wound with a coil of high-resistance, I, coupled as a shunt on the arc, having a movable iron core which is adjusted by the screw L.

In the event of the resistance of the arc increasing to too great an extent the shunt coil pulls strongly on the lever M, causing it to press together by means of the insulating stud O′ the contact points P Q, thereby short-circuiting the arc through the coil I′, which increases the pull on the lever and ensures good contact between P and Q.

The lamp may be made to strike any desired length of arc and feed at any potential by altering the position of the contacts N O. The potential on the armature of the motor is 2 volts. As during the time the lamp is in action the carbons can only move under the action of the motor, perfectly steady burning is ensured, more especially as the shunt coil has only to alter the position of the lever, so that any accidental friction in the lamp does not in any way affect the feeding point. Figs. 2 and 3 give front and back views of the lamp.

Lamps of this description have been burning for some time past at Kensington, two in series on the 100-volt incandescent circuit of the Kensington Court Company, and have given every satisfaction.

These lamps, which are also made focussing or double carbon, are constructed by the Planet Electrical Engineering Company (Limited), Victoria-mansions, 28, Victoria-street, Westminster.

ECONOMICS OF PLANNING AND CONSTRUCTING ELECTRIC LIGHT AND POWER STATIONS.*

BY ALEX. P. WRIGHT.

(Concluded from page 625.)

The dynamos required for immediate and intermediate use being decided, probably it would be well to look to the ultimate requirement before settling upon the subdivision of power and the arrangement of engines and shafting. In view of the fact that increases in business will come very quickly, it will be well to bear in mind a scheme for the future arrangement of the station in order that when the time comes for extension, as a matter of addition only, and not a combination of subtraction and addition. The machines which might be used for immediate work and increase, or at all events provision for a portion of the increase, and those which might be suitable for the ultimate capacity, are compared in the following adjacent columns. Circumstances may necessitate the changing of the particular units of capacity, in each case when the immediate location and designing of the building is done, but as a basis upon which to bring about a settled plan a beginning has to be made.

Dynamos—Immediate and Intermediate Use.

Full arc	Two 40-light	= 80 lights.	
Divided arc and	One 20 „ / Four 45 „	= 200	„
Incandescent and (Alternating)	One 650 „ / Two 1,500 „	= 3,650	„
Exciters	Two dynamos.		
Motor	One 80 horse-power generator.		

Dynamos—Ultimate Use.

Full arc and	Two 40-light / Five 50 „	= 330	lights.
Divided arc and	One 20 „ / Eight 45 „	= 380	„
Incandescent and (Alternating)	One 1,500 „ / Two 3,000 „	= 7,500	„
Exciters	Three dynamos.		
Motor	One 80 horse-power generator.		

The capacity of incandescent machines appears to be somewhat lower than the cases A, B and C, which have been assumed as the immediate, intermediate, and ultimate requirements; but experience has shown that not only in electric lighting but in gas lighting, the larger the installation of lamps, as a rule, the greater the proportion not in use at any given time, and this is evidently the case where general lighting is considered. There is not apparently in the above comparision much allowance made for the intermediate increase, but that this will be provided for will be evident when the shafting is laid out. It is proposed to lay out the plant on paper for the ultimate capacity, in order that the building required to accommodate extension may be designed, after which only such of the machinery as may be required for a slight advance on immediate requirement need be provided for, with shafting and power for the increase to such an extent as circumstances may direct.

There are some differences of opinion as to the arrangements for exciting currents. Some believe self-exciting dynamos to be superior, others that individual exciters for each dynamo are better, and others that several exciters, each capable of exciting all the dynamos, are the best. The writer, early in the history of alternate-current installation, adopted the latter plan, for the following reasons:—In the event of the exciting coils only of an armature giving out the armature is rendered useless without a separate exciter; secondly, where, say for instance, two exciters are provided for these alternate-current machines, each doing a portion of the exciting, in the event of an accident to one exciter, by proper arrangement of the switchboard one of the others can be quickly connected to supply the place of the disabled machine in addition to its own work. Thirdly, although objections have been made to this arrangement on the grounds that it is more costly both for first cost and for operation and space, the increase is so slight as compared with the total cost of the plant, and such flexibility and provision for accident is provided, that the small comparative cost may be neglected without incurring the criticism of want of economy. As a rule, in electric light stations practically no provisions are made for relay, even in many cases it being deemed unnecessary to provide spare armatures. The latter precaution is not intended as a slight upon the durability of armatures in general, and while we are not anticipating that they will be repaired except in extraordinary cases, when they are wanted they are wanted very badly, and a regret is felt that such a provision has not been made. Want of relay has cost many a station dearly, not only in actual expenditure but in loss of income and annoyance to customers.

The determination of power for immediate use, bearing in mind the ultimate power required, should be considered after the determination of the dynamo units. Economy in power appears to the writer only to be obtained by the use of such an arrangement of engines as when running alone or combined should correspond with the power required for the dynamo's loads existing at any given time, in order that at all times the engines may be running with loads within the range of their best efficiency. Comparing the requirements called for by the power curve already given with the ultimate requirements, based upon the same experience, we would get comparison of subdivisions of power as follows:—

Time o'clock.	Immediate maximum requirements.	Time o'clock.	Ultimate maximum requirements.
12 to 5 a.m.	125 H.P.	12 to 7 a.m.	450 H.P.
5 to 9	175 H.P.	7 to 3 p.m.	250 H.P.
9 to 3 p.m.	125 H.P.		
3 to 12 night	560 H.P.	3 to 5 night	1,300 H.P.

First making a division between the present and future loads, it is found on comparison that 560 horse-power and 1,300 horse-power are the totals, so that for the moment disregarding the respective variations, and basing only on the maximum loads, a division into 560 horse-power and 700 horse-power for increase would fill the bill—the 600 horse-power for immediate and an additional 700 horse-power (total 1,300 horse-power) for ultimate capacity. Taking up the subdivision of the 600 horse-power, probably the 700 horse-power will not require much subdivision; the variations in the first column of comparisons gives us variations of 125, 175, and 560 horse-power respectively. Divisions of 125 horse-power, 250 horse-power, and 350 horse-power would either singly or combined give a good arrangement for the present, leaving some surplus power (about 165 horse-power), a margin which at times will be more than acceptable. This arrangement, while allowing considerable flexibility, will allow of running with varying loads at an economical point of cut-off. The combinations of such powers would be as follows (in horse-power):—

125	125 + 250 = 375
250	125 + 350 = 475
350	250 + 350 = 600

125 + 250 + 350 = 725.

Comparing these arrangements with the curve it will be evident that at all times the engine would be operating at economical cut-offs if properly handled. Before finally determining this arrangement it will be well to consider their combination with the proposed ultimate increase.

The addition of one unit of 600 horse-power would be suitable, with the ability to maintain the desired flexibility. Continuing the combinations, we would have (in horse-power):—

600	350 + 600 = 950
125 + 600 = 725	125 + 350 + 600 = 1,075
250 + 600 = 850	250 + 350 + 600 = 1,200

125 + 250 + 350 + 600 = 1,325

* From *Modern Light and Heat* (Boston, U.S.).

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Before the final increase to the plant probably the wisdom of doubling the 125 horse-power units would suggest itself, and it would, therefore, be wise to provide a single engine with foundation, shaft and fly-wheel ready for duplication, even if it were not decided to make the installation in the first instance, with one engine disconnected but ready for connection at a few minutes' notice, if required at any time, to take care of accident. If the idea of compounding were entertained, this might reasonably be done if all the engines could be worked near and at their full capacities. If the first engine was not immediately duplicated the high pressure side of it might be set up with a view to compounding, provided it were decided to use right-angled engines rather than tandem compounds. The use of right-angle engines will have this advantage—that either side may be disconnected at any time for overhauling, and in case of disablement of one section the other runs at high pressure if the piping be properly arranged, as was arranged for by the writer in the new station at Springfield, Mass., thus giving greater relay in the event of accident. The importance of provision against accident cannot be too definitely borne in mind, and particularly the ability to seize the opportunity of small loads for overhauling and inspecting engines. The subject of condensing we think needs no argument, and resolves itself into the use of individual condensers connected with each engine, or independent condensers, the latter being perhaps preferable.

The particular make of engines can be left until after the general plans are made, as will also be the case with the shafting and pulleys, pumps, condensers, heaters, boilers, &c. The successful use of friction clutch couplings and friction clutch pulleys has now been so demonstrated by actual practice, and the advantages to be obtained by their use being so great, there appears to be very little question as to their use in first-class plants. As far as designing the stations with large engines and shafting is concerned, there is now sufficient general data from which the engineer can prepare plans.

If it is decided also to consider the preparation of plans contemplating the use of smaller engines belted direct to the dynamos, the data required, in addition to that included above, will be the probable schedule of engines to be used. Setting down, therefore, the schedule of dynamos already accepted, with the power required for each arranged in a final column, showing, by brackets, the engines required and the machines to which they are to be coupled.

	Dynamos.		Power required by each.		Engines.
Full arc ...	Two	40-light ...	40 horse-power ...	=	80 horse-power.
„	Two	50 „ ...	50 „ ...	=	100 „
„	Three	50 „ ...	50 „ ...	=	150 „
Divided arc..	One	20 „ ...	15 } „ ...	=	75 „
„	Two	45 „ ...	30 }		
„	Two	45 „ ...	30	=	60 „
„	Two	45 „ ...	30	=	60 „
„	Two	45 „ ...	30	=	60 „
Incandescent	One	1,500 „ ...	150	=	150 „
„	One	3,000 „ ...	300	=	300 „
„	One	3,000 „ ...	300	=	300 „
Motor ...	One	80 „ ...	80	=	80 „
Generator ...		—	—		—

Summarising, there will be required :—

Three	60 horse-power engines	= 180	horse-power.
One	75 „	= 75	„
Two	80 „	= 160	„
One	100 „	= 100	„
Two	150 „	= 300	„
Two	300 „	= 600	„
	Total	1,415	

The exciters will be distributed amongst the incandescent engines, and the 650-light incandescent machine could be connected with one of the 65 horse-power engines until change were required. Immediate requirements therefore call for :—

	Dynamos.		Engines.
Full arc.....	Two	40-light.....	80 horse-power
Divided arc	One	20 „ }	75 „
„	Two	45 „ }	
„	Two	45 „	60 „
Incandescent.....	One	650 „	60 „
„	Two	1,500 „ .....Two	150 „
Motor generator		80 „	80 „

Summary.

Two	60 horse-power engines	= 120	horse-power.
One	75 „	= 75	„
Two	80 „	= 160	„
Two	150 „	= 300	„
	Total.....	655	„

There are now two sets of data from which to plan stations for similar purposes, upon which an engineer can prepare general plans, with a view to the choice of a suitable location, in which work he should be left without interference, his plans and estimates being eventually submitted for approval, or as a basis upon which to make such alterations and improvements as circumstances may direct.

THE INSTITUTION OF ELECTRICAL ENGINEERS.

Underground Conduits and Electrical Conductors.*

BY JOHN B. VERITY.

My object in bringing this subject before you this evening is to promote an interchange of opinion and experience concerning one of the few remaining problems connected with the general distribution of electricity in our cities. Since I began to write this Paper, on my return from America, much information has appeared in the electrical press, and the close attention now being paid to the matter in America is equalled by a like spirit of inquiry here. The outcry against overhead wires has been gaining in force, and although the numerous objections urged are devoid of solid grounds, there is a general feeling that any considerable extension of overhead cables for electric lighting is impossible, both on account of the difficulty and no inconsiderable expense in procuring way leaves, and also the attitude taken up by the Board of Trade and others to put a stop to them. Overhead wires in this country may therefore be simply considered as a temporary measure to admit of the Electric Supply Companies getting to work, and permitted only on the distinct pledge of the removal of such wires within a certain distance.

The time allowed for the execution of underground works in Provisional Orders and licenses, although as long a period as could be obtained, is all too short, and a thorough discussion of the subject at the present time, in its numerous aspects, is highly advisable to enable it to be afterwards promptly and adequately dealt with.

In three months we may reasonably conceive that certain Electric Supply Companies will be under legal obligations to at once face the problem of putting high tension electric conductors underground. It will be no petty attempt narrowed down to a small area, but in two special instances the undertaking is proposed to be carried out on a large scale by companies of adequate financial resources and with supply stations already erected or in process of erection.

"Is failure probable?" may seem a singular question to put here, but it is a necessary one leading up to the various difficulties to be encountered, and, in view of the alarmist statements at the recent Electrical Convention in Chicago, one that deserves prominence. Mr. Lynch's Paper giving the results of the working of underground cables, and which was practically the only part of the meeting reported in the English papers, showed but one side of the case, and from the discussion following it (and which appeared in the *Electrical World*, March 2) much was to be learned. Many of the companies operating underground cables had from some cause or other not given their opinions, and the failures alluded to were in several instances traced to defective conduits, insufficiency of insulation, poor insulation, imperfect jointing and cheap work. Cheap work has damned electrical enterprise before now, and it behoves us all to guard against a recurrence of it. Anything also on the subject of conduits and underground electric conductors emanating from American electricians has to be carefully sifted, as not even are our Unionists and Home Rulers more defined than certain "overhead" and "underground" men in America. The overhead men accuse all the underground men of being interested in some of the dozen forms of conduits put forth, the underground men retaliate by saying, "You don't want to go underground," and "You boldly say we cannot go underground."

In England we stand on a different footing altogether; if much more electric lighting work is to be done we must go underground, and having recognised that, how can it best be done? The necessity and best form of conduits are the first points for discussion.

The successful working of a system of underground electrical cables in a city must be linked to an arrangement of ducts, as the impossibility without such of getting at the cables for repairs, inspection, tapping and alterations is evident. Even if the local authorities remained quiescent during any continual disturbance of our streets on account of electrical conductors, commercial interest must prevent such occurring. The expense of opening up a crowded thoroughfare to lay underground cables is in many cases as great as the cost of whatever is being laid, while by using a duct this expense once incurred should not be again necessary. Again, if the cable be laid in the ground without a duct, it is necessary to armour it and lay it down at first equal to all possible requirements, otherwise any extension of the lighting beyond the capacity of the cable would necessitate a repetition of the whole original work. In this case the first cost of such a large cable would be nearly as great

* Paper read before the Institution of Electrical Engineers, April 11, 1889.

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as the smaller cable and duct together. Finally, the life of the best cable for high-tension currents cannot at the present be predicted, and this, together with the other reasons, undoubtedly prove that a conduit with a drawing in and out system is eminently desirable.

An ideal system for underground work is a brick subway, well drained and ventilated, and of sufficient size to permit of a man working in it; failing this Utopian arrangement, what comes next best? In New York, where the matter has been placed in the hands of a Board of Electrical Control, they start out by saying that a conduit or subway for electrical conductors is nothing more than a mechanical protection for the wires within it and a convenience for placing or putting them underground. In their experience of three years the Board of Electrical Control have naturally tried and abandoned many conduits. In a room of the Telephone Building, New York, occupied by the Subway Construction Corporation, there is a heap of experience—experience gained at no little cost—that it would be of advantage for engineers who lightly propose undertaking such work to see and meditate on. Wooden conduits, bitumen conduits, asphalte conduits, earthenware conduits, samples of underground conductors—all are here in what is termed the museum, and afford a collection of failures most instructive as to *what not to do*.

In many instances, however, the conditions there would not apply to England. At present we have no system of steam heating with leaky pipes, causing trouble wherever they go. Again, here we have not those great extremes of heat and cold, the frost compelling conduits to be laid at an average depth of four feet and the heat causing various troubles with asphalte and bitumen conduits.

At the same time, from the numbers of miles of conduits laid down there should be something to learn, and I therefore propose instancing some of the more important conduits known in America and elsewhere.

Conduits are divided into two classes—the so-called solid conduit and the hollow conduit. Solid conduits are useless considering here, as they practically consist of cables bedded in asphalte or bitumen, which means ripping up the ground and breaking the enclosing mass if alterations are required. With hollow conduits, the difficulties to be encountered seem to be to provide a smooth channel, with convenience for drawing in and out to prevent explosions through accumulation of gas, and to keep them reasonably dry and water-tight.

In the discussion at Chicago it was stated that in one instance it was necessary to keep a blower going to ventilate an iron conduit, while several authorities appear to consider it advisable on dry days to take off the manhole covers. Accidents have, of course, occurred from conduit explosions, and the engineer of the United States Electric Lighting Company instances one where the manhole covers of the conduit were blown over the roof of a four-storeyed building. But in England, again, the work done by the Gas Companies is far better, and the leakage in our streets is not in any way to be compared with the quantity of illuminating gas which wanders, fancy free, through the soil of many of the cities of the States.

It appears desirable that conduits should be ventilated, and the form adopted, where possible, is to ventilate them by means of a pipe running into the base or up the interior of the street lamp-posts. With regard to keeping them water-tight, this is another constructional question surely capable of being properly dealt with.

Many of the complaints of leaky conduits and ultimate failure of cables I trace back to the Dorsett conduit.

This, one of the earliest forms of conduits, is built of blocks formed of a combination of coal-tar pitch and fine gravel, cast with tubular openings 2½in. in diameter running through them from end to end. They are jointed by pouring soft mastic into the cracks between them, and the blocks made to adhere to this by warming their ends with hot irons and allowing them to cool, after being well set. To prevent the melted mastic from closing the ends of the passages, tubular pieces of paper are inserted, making a sort of internal sleeve coupling. The conduit so formed terminates in brick manholes at the street crossings. The objections to this conduit are that it is brittle, porous, inelastic, and cracks with changes of temperature, so that it is not likely to be made water-tight with average workmanship.

Creosoted wood conduits have been extensively used in the States, and have been a leading cause of trouble and failure with lead covered cables. A chemical action takes place between the crude creosote and the wood, setting free acetic acid and carbonic acid gas, which, reacting on the lead pipe, converts its surface into a film of acetate of lead, the action continuing until the entire sheathing is converted into carbonate of lead or white lead. Creosote is also said to rot rubber. There are, of course, ways of overcoming such troubles, but as I do not think we shall be disposed to use creosoted wood conduits in this country, the matter need not be given much prominence here.

The difficulty of obtaining a conduit that shall be anything more than a mechanical protection for the cables is certain to be great, as however good the insulating material forming the conduit may be, and however water-tight the joints, there is a difficulty in excluding dampness unless it is practically air-tight, as damp air enters the conduit and condenses on it.

Several conduits have been made, however, with a view to afford electrical as well as mechanical protection to the cables. The Callender bitumen conduit, for instance, is well known here. It is

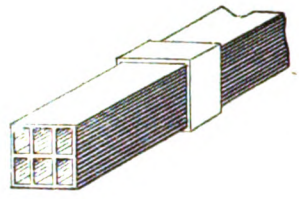

Fig. 1.—The Lake Conduit.

being extensively laid down by the Chelsea Electric Lighting Company, and five hundred yards of it is being tried by the Metropolitan Electric Supply Company. For high-tension currents its use

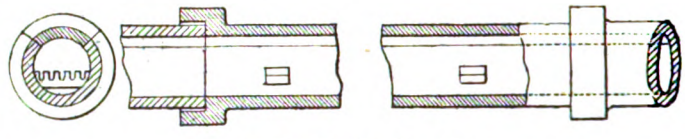

Fig. 2.—The Doulton Conduit.

is doubtful, but perhaps in the discussion something may be said on this point.

Vitrified 3in. sewer pipes laid in concrete with cement joints have been used in some instances for underground work.

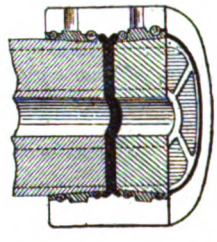

Fig. 3.—The Hurlbut Conduit.

The Lake conduit shown in Fig. 1 is made from the best stoneware clay vitrified and well glazed. This conduit, said to be used with success by the United States Electric Lighting Company at Washington, is constructed with six compartments, each being

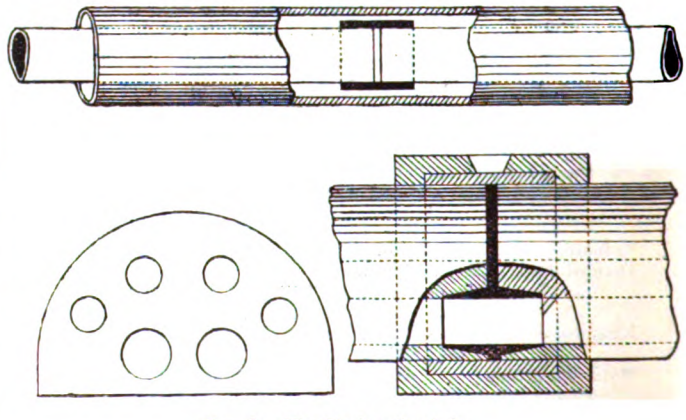

Fig. 4.—The Verity Conduit.

2½in. by 4½in. It is delivered in short lengths, and the joints are protected by stoneware covers set in cement.

The Doulton conduit (Fig. 2) consists of a glazed earthenware pipe, in which the cables are laid separated by toothed insulating partitions. A space at the bottom drains off the condensed moisture, which is got rid of by suitable traps. The joints are made like ordinary drain pipes.

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A serious objection to such conduits seem to be the joints which are made with cement. It is very difficult to break a cement joint without also breaking the pipe, and as it might be necessary at times to put in a new length, this could not well be done. Again, the rigidity of a cement joint is a disadvantage, as in laying earthenware pipes it becomes necessary at times to alter the alignment.

The Hurlbut Conduit System (Fig. 3) was designed to overcome this difficulty by means of a flexible joint. The joint is shown in the diagram. C represents asbestos gaskets recessed into the coupling and resting against the pipe. B is a cavity formed between the asbestos gaskets and is filled with a permanently plastic sealing material. A represents openings through which the sealing material is poured. It is claimed that such joints will always remain both flexible and hermetically sealed.

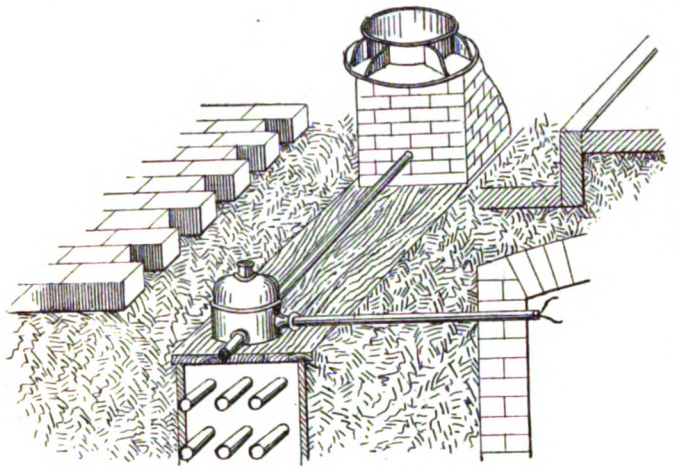

FIG. 5.

Mr. B. Verity's Conduit (Fig. 4). This is a system of glazed stoneware clay conduit with separate channel for each conductor; the joints are made as shown on diagram, the double cone piece being inserted before the jointing material is run in. The special object of this conduit is to enable bare conductors to be used insulated only at the manholes or where they are likely to be handled. Experiments have proved this form to be capable of standing almost anything mechanically when laid on a fairly good bottom. Mr. Verity has also patented a system of glass tubes in iron pipes for the same purpose.

Pipes of glazed earthenware with several ducts form a good mechanical protection, being capable of resisting considerable crushing pressure, while the glazing both inside and outside provides also, under certain conditions, a first-class electrical protection. If it be desirable that the conduit should be formed of a non-conductor, then nothing could be better than such glazed earthenware, which also is of no great cost. The difficulty of maintaining good joints with earthenware pipes has been referred to some time ago in connection with conduits for telegraph purposes, several instances having been given by Mr. Preece and others of roots of trees, branches, and other vegetation having made their way through the joints. Is this capable of being overcome by a flexible joint, which should at any rate prevent joints giving through expansion and contraction?

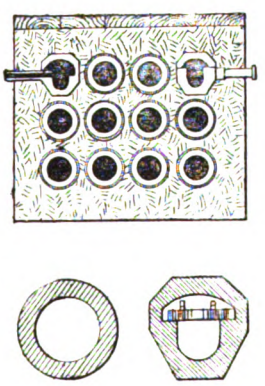

FIG. 6.

The great disadvantage, however, to the use of earthenware pipes in many places in a city like London is the amount of space required for them; in fact, the difficulty of laying any conduit at all in some of our streets will be found simply enormous.

As a mechanical protection only, it is immaterial whether the conduit be a non-conductor or not. The simplest form of such a duct is, of course, an iron pipe, and the Western Union Telegraph Company among others have laid cast-iron pipes of 4in. and 5in. diameter with manholes at a distance of about 450ft. apart. In the majority of cases, however, the plan has been to lay a number of separate iron pipes in a concrete bed, by which arrangement the pipes can be crowded, or curved, or kept apart, as may best overcome any difficulties or obstacles met with underground. For instance, four pipes may be laid on the same level in two layers, or where only a narrow excavation can be made, the pipes can be curved round so that two pipes are abreast in four layers. In this way the trenching is often materially diminished. Screw-jointed, asphalted, wrought-iron pipes of two or three inches diameter laid in hydraulic cement concrete are said to present the greatest tightness of duct against gas and water, together with the greatest strength. (See Figs. 5 and 6.)

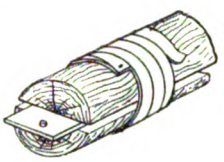

FIG. 7.—The Chenoweth Conduit Core.

Cement lined sheet-iron pipes, however, possess some advantages, such, for instance, as smooth interiors and the advantage of an iron enclosure without the cable being brought into contact with it, and on the sheet iron being eaten away the cement still retains the pipe form. Zinc tubes again have been used, but are liable to be dented in, and asphalted concrete is often preferred to hydraulic cement concrete.

Whatever system of pipes be used, it is important that they should have smooth interiors and close joints, and every conduit of whatever kind must be thoroughly well bedded, so as not to be liable to displacement from above.

An ingenious conduit core (Fig. 7) has been devised by Mr. Chenoweth: a wooden cylindrical rod, 14 or 20 feet in length, is cut in two, forming two half-cylinders, and the space removed is occupied by an iron rod having a thickness equal to the portion sawed out. This forms the mandrill or core shown in the illustration; a ribbon of galvanised iron 1in. wide and a thickness of No. 27 gauge is wound spirally round this from end to end, securing the ends to the wood to prevent unwinding.

After painting the outside of the core with a mixture of clay, soapstone and water, the core is placed in the ditch on crossed pieces of wood. If more than one duct is to be constructed, other cores are placed side by side, concrete is then well tamped round, bringing the top to an even level. The iron rod is then removed, as well as the two pieces of wood and the fastenings of the ribbon ends. When the cement hardens, the iron spiral can be drawn out at any manhole or unfinished portion of the work. It is claimed that the surface coating of clay and soapstone adheres to the interior of the duct and produces a smooth surface, while a monolithic structure is ensured water-tight by reason of its construction. I think this is another instance of American ingenuity.

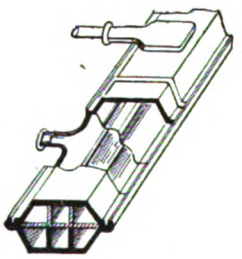

FIG. 8.—The Johnson Iron Conduit.

The Johnson Iron Conduit shown in the illustration (Fig. 8) is said to be very successful, and I saw portions of it as designed to be laid in New York City. It is made in sections about 6ft. long and has six ducts; the three lower ones and the central duct on the top could be used for mains, and the two outer top ducts for

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house-to-house and street lighting. Where any house circuit is required, the top half of a single section is taken and a new half-section with a hole in it, to which an elbow can be bolted, is fixed in its place.

A form of conduit made by Mr. W. E. Irish, of Cleveland (Fig. 9) is also worthy of notice. In the illustration the conduit consists of a tubular pipe cast in sections, with flanges which are recessed on the inside to receive a rubber ring forming a gasket between the two sections when bolted together. The conduit is provided with a longitudinal slot, or opening along the top, with inwardly inclined sides and flat surfaces on either side of the slot, to which the cover is secured by screws. To prevent the entrance of moisture through this slot, a strip of rubber or leather is first laid on the top of the flanges extended from one outer edge to the other. On this a solid wedged-shaped piece, which fits into the slot snugly, is placed so that on the cover being screwed down the wedge with the packing surrounding it is forced into the slot so as to seal it perfectly. It is claimed that there is great convenience in laying wires with this conduit, and that any wire can be tapped at any point by simply removing the cover and making the necessary connections. The illustration represents the conduit with a branch, also a junction box, &c.

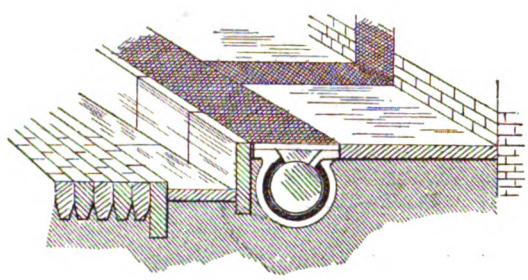

Fig. 9.—The Irish Conduit.

Figure 10 represents Mr. J. E. H. Gordon's system as used by the Metropolitan Electric Supply Company; the cables are drawn into an iron pipe and smaller iron pipes are led from the house junction boxes to carry the wires for house lighting. Testing boxes of a larger size and built of brick are provided at intervals.

It is generally admitted that an important point in underground work is good manholes. Mr. W. D. Sargent, in a paper read before the National Telephone Association, 1888, said that within reasonable limits it is almost impossible to get these manholes or working chambers too large, and that they have been compelled in many instances to rebuild and enlarge the manholes at first designed.

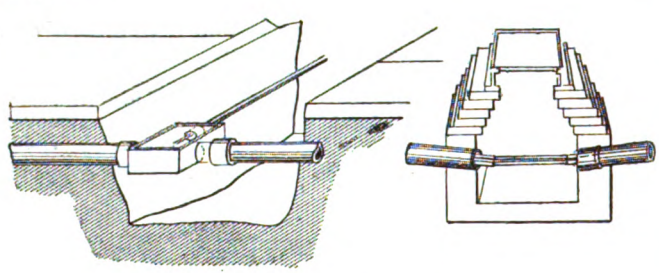

Fig. 10.—The Gordon Conduit.

There is no doubt they must be of good size for convenience of drawing in and out, which is often a difficult matter, especially with lead-covered cables. In one instance, in Chicago, the manholes are built in octagon shape, in brick and cement, about 4ft. by 4ft., being made air-tight with screw head and rubber gasket, and testing boxes placed in them, so that troubles can be readily located, faulty wires drawn out, and good ones put in. In other cases the manholes vary from 3ft. 6in. to 6ft. deep with iron curbs and tops and cement bottoms, and the covers made practically tight against water, many of the lids draining the water from the edge and collecting it in the centre, thus diminishing the liability to leakage at the gasket. With the Johnstone and the Irish conduits, it is not necessary to provide for house connections, as the alteration can be made at any time afterwards when an application for light is received. But, as a rule, hand distributing boxes, made of cast iron with screw-head and rubber gasket, are fixed one between every two houses, and after jointing the boxes are often filled with bituminous or insulating compound. In the cement-lined pipe conduit system one pipe is occasionally placed at the top for the house distribution and connections made with the mains at the manholes. As to the frequency of these latter, much depends on the alignment of the conduit; at angles or changes of grade small manholes are necessary.

The combination kerb and gutter conduit (Fig. 11) shown in the illustration, is worth notice. The kerb and gutter is made of fine concrete, one part of Portland cement, ten parts clean sharp sand, and three parts of broken stone, and the exposed surfaces coated with a granilitic mixture, 1½in. thick, such as is now used for some of our London pavements. A conduit for electrical conductors of any reasonable size can be formed as shown in the inner angle of the kerb with handholes from above closed with iron covers at intervals. The illustration is taken from the admirable report on underground wires by Major Raymond, the engineer, Commissioner for the district of Columbia, and which contains valuable information on many points.

It has been snggested some time ago that the kerb stones should be removed from busy thoroughfares and replaced with a hollow kerb edged with cast steel, and the suggestion may bear fruit in the future.

As I still have to deal with electrical conductors I cannot here refer to the general cost of laying conduits as at one time I proposed

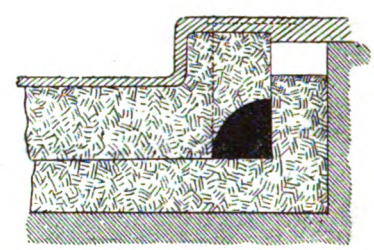

Fig. 11.—Combination Kerb and Gutter Conduit,

doing. The principal cost, however, of laying them is in making good, and this depends on the material of the road, the cheapest being macadam, varying from 5s. per square yard, whereas asphalte would be nearer 20s. per square yard.

The difficulty of laying any form of conduit in some of our London streets must, as I have already said, be very great. The last comer will of course feel this the most, and although the Hydraulic Engineering Company may have recently had much trouble to find room for their pipes, the Electric Supply Companies again will have an easier task than the Telephone Company, who are putting off the evil day.

As to what form of conduit is most suitable for London and our provincial cities there will be differences of opinion, but I trust the discussion following will narrow it down to a small issue upon which such work can be undertaken with a tolerable surety of its lasting success.

(To be continued.)

SOME ELECTRIC LIGHTING CENTRAL STATIONS IN EUROPE, AND THEIR LESSONS.—Part I.*

BY PROF. GEORGE FORBES.

(Concluded from page 681.)

Rome.

The station at Rome, started by the gas company in that city, is the finest example of an alternating-current central station which I have yet seen. But it has been very costly to establish. Many of the details contain hints of the greatest use to those who are at work on this subject. The whole plant has been contracted for by Messrs. Ganz, of Buda-Pesth.

There are two self-exciting alternators of 150 horse-power each and two independently excited ones of 600 horse-power each. These give 42 amperes and 160 amperes respectively, and 2,000 volts. At present 9,000 glow lamps of 16-candle power are supplied and over 200 arc lamps. All the machines are capable of working in parallel, even the large and small ones together. The number of alternations is 5,000 per minute, or 2,500 complete periods. The greatest distance to which current is at present supplied is 4½ kilometres, or about three miles. The feeders all go to the Piazza Venezia, and then branch off into three mains in different directions. The loss in the secondary circuits due to loss in the feeders

* Paper read before the Institution of Electrical Engineers, February 28, 1888. Part II. has already appeared in our issue of March 8.

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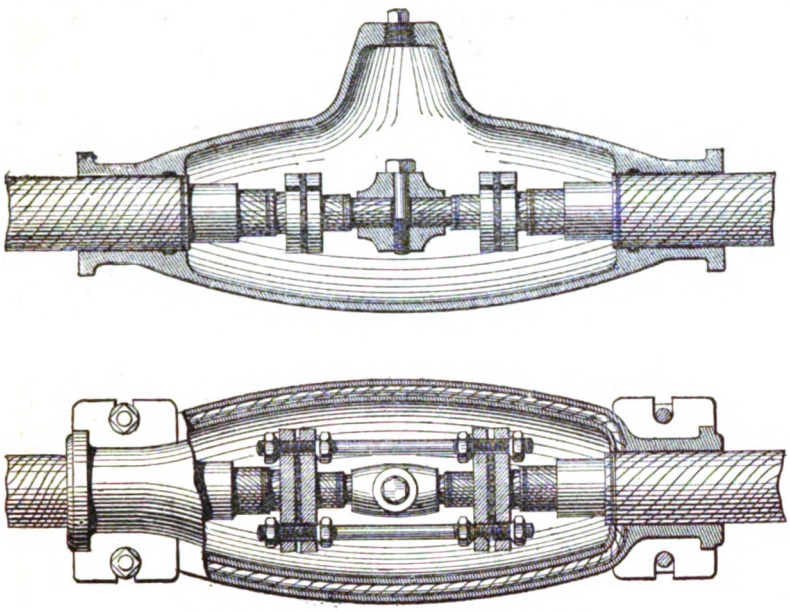

FIG. 2.—Junction Box by Siemens and Halske.

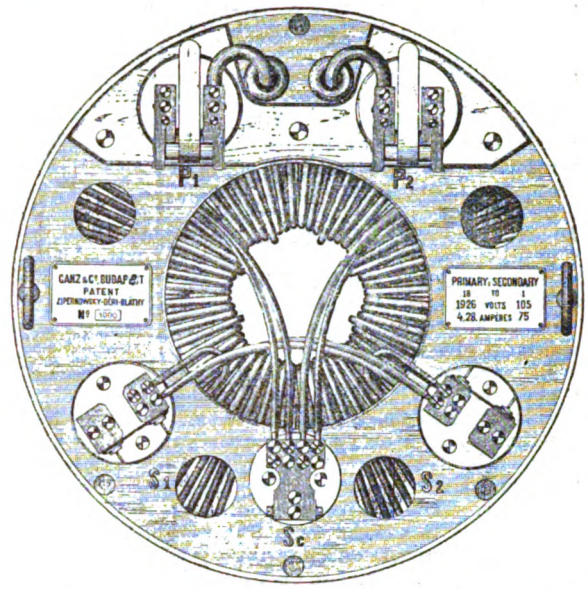

FIG. 3.—Zipernowski 7·5 Unit Converter (scale $1\frac{1}{16}$ in. to the foot).

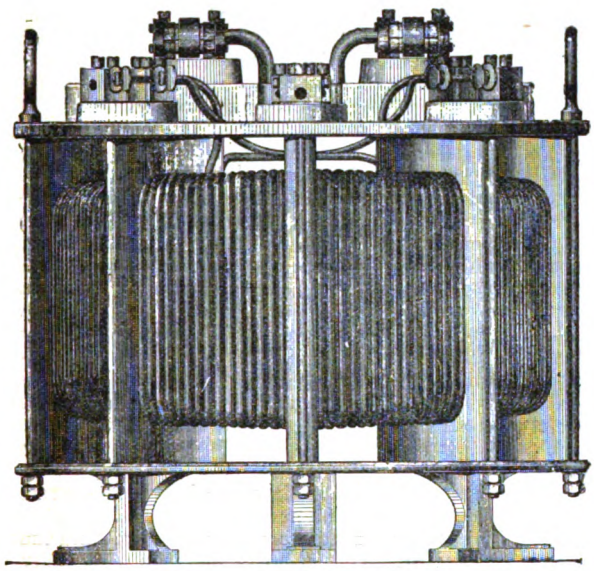

FIG. 4.—Zipernowski 7·5 Unit Converter (scale $1\frac{1}{16}$ in. to the foot).

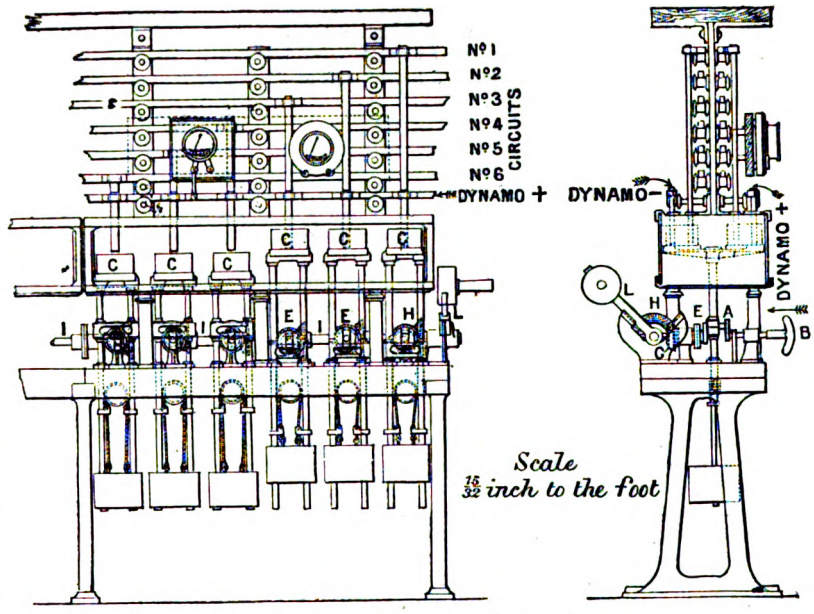

FIG. 6.—Rome: Mercury Switchboard.

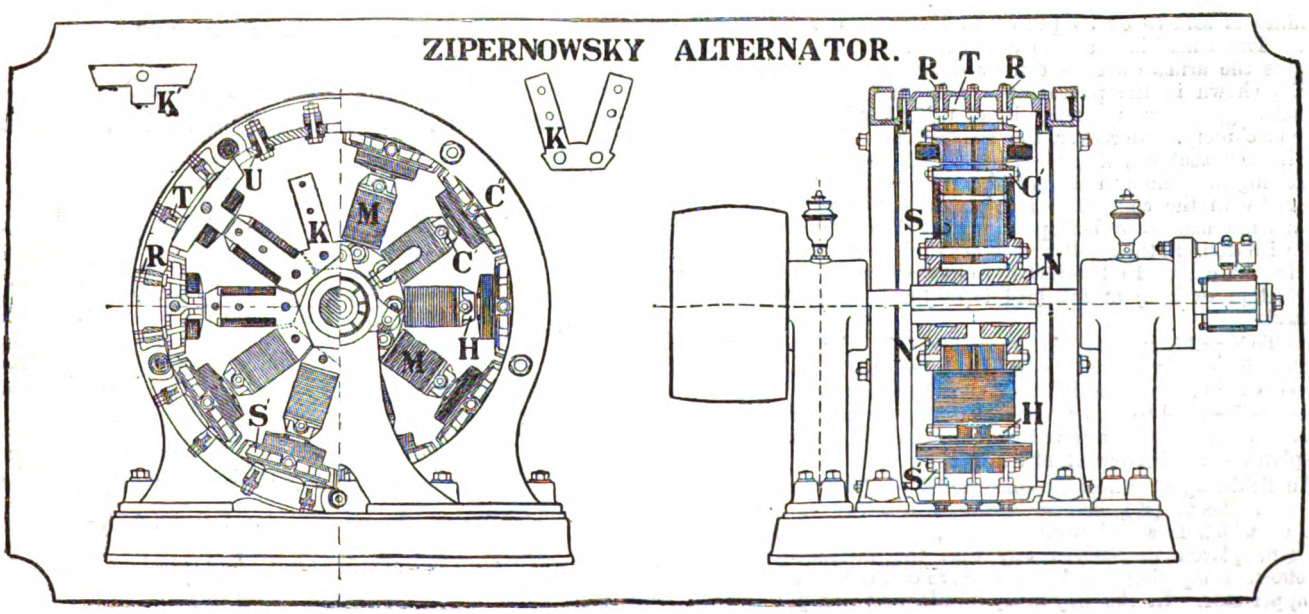

FIG. 5.

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at present is only 0·6 volt at the maximum and that due to the mains is the same, the length of feeders being 1,600 metres.

Siemens concentric conductors are used throughout. The feeders are each 220 square millimetres section, or 0·35 inch. Drawings of the junction boxes by Siemens and Halske are shown in Fig. 2, indicating the means of attachment by clamps of the two ends of the inner and outer concentric wires. The cables are laid in a wooden box which is then filled with cement. Seventeen kilometres of cable have been laid up to January, 1888. The feeders have been working since September, 1887. The transformers are all of 10 horse-power, with about four amperes in the primary and 75 in the secondary. 110 volts are used in the secondary, but the secondary coil has three terminals, one half-way along the length of wire. This is to enable a three-wire system to be used for the secondaries when arc lamps are used, consuming with their resistances 55 volts each.

The old type of converter with iron wire wound round the copper coils has been abolished. The iron part is built up of circular flat ring-shaped discs of iron. These are firmly clamped together by iron clamps which form the support of the instrument. The copper coils are wound upon the segments of the rings between the clamps. The primary coil is underneath the secondary. The converter has an iron circular disc at top and bottom fixed to the clamps, and this enables the instrument to be easily rolled about without injury, which facilitates handling. On the top is a porcelain disc on which are placed the terminals and fusible cut-outs. These are short strips of thin metal held in pasteboard, and can be slipped in and out with the greatest ease. Drawings of these converters are shown in Figs. 3 and 4.

The small machines are intended to work 1,000 lamps of 60 watts. There are twenty poles, and 250 revolutions per minute. A derivation is taken from a commutator to excite the machine. Sulzer engines are used for these dynamos, acting direct on the dynamos. The steam pressure is 120lb.

The automatic resistance for regulating the exciting current, invented by M. Bláthy, is very effective. The exciting current passes through a solenoid actuating an iron rod which is supported at one end of a balanced lever. The bar is weighted with a float in water, and water can be put into the float. On the top of the iron bar is a cup of mercury which, in falling, breaks contact with the ends of wires dipping down into the mercury cup. These ends are at different depths, so that the wires are cut out of circuit in succession. The wires go to resistances. This automatic adjustment acts well over a considerable range.

The exciters for the large dynamos are driven by Westinghouse engines. They are governed by hand for the large changes, and then the automatic regulation comes in. Such a method of regulation is necessary with machines having so large an amount of self-induction. This is the only satisfactory regulation of the kind which I have seen at work. It is one of the small details on which the success of a station depends, but which are often forgotten by the inexperienced until the want is felt.

The two large machines have forty poles each on the revolving field-magnets. Both field-magnets and armature are divided into two series in parallel. When the machine is illuminated by an arc light, to which it supplies the current, a curious optical effect is produced. The arc being periodically made and broken, the revolving magnet-poles are seen fixed in position, and the amount of lag with different loads can be seen directly. The efficiency of these machines is said to be 90 per cent., including the exciting current. These machines are so constructed that the cover which contains the armature coils can be drawn away, by means of a handle, shown in the photographs exhibited, over the electro-magnet ring, without the necessity of using any hoisting tackle or other machinery. Moreover, the construction of the fixed armature is such that any single coil can be removed in a few minutes or exchanged. The iron of a section of the armature is in this case removed with the coil. The iron plates of which these armature sections are made are T-shaped, so that the centre of the coil is filled with iron. In the smaller machines there is not nearly so much iron in the coils. In the 600 horse-power machines the energy absorbed in exciting at full load is said to be 3½ per cent. of the full load.

The T-shaped iron plates of the armature (K^1) (Fig. 5) are pressed together by strong bronze press plates (S^1, S^2) and a screw (C'). The wire bobbin is then slid on and held by screws. These segments are fastened to two traversers (T) by the screws (R), which traversers are in turn screwed with an insulating layer (U) to the side-plates of the framework of the machine.

The field-magnet wheel is constructed as follows:—U-shaped soft iron sheets (K), are so arranged together as to form a star, to which is added a similar star, with an insulating layer between, placed in such a way that the interstices between the sheets composing the lower star are covered by the sheets of the upper star. In this way many iron laminæ are put one upon the other until there are sufficient to form the whole electro-magnet wheel. The pile so formed is then pressed together to form a compact whole by means of two stiff discs (S), two bosses (N), and the screws C. The bobbins M are slipped on to the core (K), and held down by means of the bobbin-holder (H) and screws (C_1). The subdivision of the iron in the field magnets is necessitated by the teeth of iron in the armature projecting inwards through the coils.

The large engines are by Ganz and Co. They are carefully balanced and are provided with starting gear.

A drawing is exhibited of the switch-board (Fig. 6), which is very ingenious but very expensive. The board is about 8ft. high and 17ft. long. It is divided into four sections, one for each dynamo, and each section is divided into six, one for each pair of feeders. A pair of 4-foot horizontal bars runs along each dynamo section, connected with the two poles of the dynamo. Two vertical bars descend from these at each of the six parts allotted to the six circuits. Six pairs of horizontal bars are connected to the six pairs of feeders (only three are as yet in use), these pairs being one over the other. At each feeder section a pair of vertical copper bars descend from the horizontal feeder bars corresponding to that section. Thus we have at each feeder section two vertical dynamo bars and two vertical feeder bars, the lower ends all being at the same level. Mercury cups can be raised to connect each dynamo bar with a feeder bar, or lowered to disconnect them. The chief object of the switch-board is to enable us to switch any number of dynamos in or out of connection with any feeders simultaneously and instantaneously. I will now describe this action, referring to the diagram. In the normal condition the crank (A) and handle (B) would be as shown in the side elevation, one crank to each mercury cup (C). If it be required to put on to the dynamo the feeder No. 6 and take off No. 1 from the dynamo represented by this part of the switch-board, the handles (B), with cranks (A), corresponding to these feeders are pushed bodily to the left; the web of each crank is thus made to fit in a vertical slot in the disc (E), which disc is connected to the bevel wheel (G) by a hollow spindle to which (G) is keyed, this bevel wheel gearing with the bevel wheel H keyed on to the shaft (I), running the whole length of the switch-board. The crank of No. 6 would be diametrically opposite that at No. 1, since one was disconnected and the other connected to a circuit. The lever (L) is then thrown over against the other stop, causing the crank No. 6 to be raised from its lowest to its highest position, and that of No. 1 to be correspondingly lowered.

The voltmeters in this station by which the pressure at the lamps is kept constant are regulated by means of two circuits, one being a shunt on the dynamo terminals and the other carrying the main current. These are passed through converters, and the secondary currents actuate a solenoid in opposite directions. This compound-wound voltmeter indicates the pressure at the lamps, and is maintained constant. Prof. Mengarini has devised an ingenious recording voltmeter for marking in a daily curve the pressure at the dynamo terminals at each minute of time. These show variations of 5 volts at different hours.

There are fifty converters now at work, each of 10 horse-power. The efficiency of these converters is 95 per cent. at full load. That of Messrs. Ganz's 5 horse-power converters is 92 per cent., and the 2½ horse-power is 88 per cent. This is far higher than with many of those now made in England. The House of Parliament is lighted by four banks of five converters each.

A METHOD OF DETECTING DISSOLVED CHEMICAL COMPOUNDS AND THEIR COMBINING PROPORTIONS.*

BY G. GORE, LL.D., F.R.S.

The method is based upon the general truth that "when substances chemically combine they lose some of their power of exciting a voltaic couple, and the amount of this power can be measured by means of the "voltaic balance" (see Roy. Soc. *Proc.*, Vol. XLIV., p.p. 151-294). It is briefly as follows:—Oppose and balance the current from a small voltaic couple of platinum and unamalgamated zinc in a known quantity of distilled water through a suitable galvanometer by that from a perfectly similar couple. Dissolve in separate, equal, and known quantities of distilled water a series of mixtures of the two constituents A and B of the supposed compound, in the proportions of their atomic or molecular weights, and multiples of them, some having an excess of A and others of B. For instance, if both are monads, mix them in the several molecular weight proportions of 5 A+4 B, -4 A+4 B, -and 4 A+5 B, but if A is a monad and B a dyad, then use 3 A+2 B, -4 A+2 B, -and 5 A+2 B. Add sufficiently small quantities in succession of one of these solutions to the water of one of

* Abstract of a Paper read before the Royal Society, January 17th 1889.

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the voltaic couples until the needles of the galvanometer commence to move, and note the proportion added. Recharge the cell with distilled water, clean the metals, red-heat the platinum to expel absorbed hydrogen, and repeat the experiment with another of the solutions, and so on until the mixture has been found of which the largest proportion is required to move the needles—that is the one which has the smallest energy, and which has its constituents united together chemically in definite proportions by weight.

By means of suitable examples the author has shown that the dissolved substances unite together in the definite proportions by weight of their ordinary chemical equivalents. He has also experimentally examined the question of the limit of complexity of chemical combination of substances whilst in solution together in water, and although a definite compound was formed having the formula K^2SO^4, $16KNO^3$, $4A_mCl$, $2N_aCl$, 8KCl, 32LCl, the limit of complexity of combination did not appear to be nearly reached.

He states that he has examined by the above method more than 180 different mixtures of dissolved substances, but has not found one in which definite chemical union is not more or less clearly indicated by a minimum amount of voltaic energy, coinciding with the proportions of the ordinary chemical equivalents of the substances. The mixtures included a great variety of soluble salts, acids, and elementary substances and their compounds. And he concludes that *every electrolytic substance, when dissolved in water, unites chemically in definite proportions by weight with every other such dissolved body*, provided no separation of substance occurs, and that they unite to form compounds of apparently unlimited complexity.

The voltaic balance method may be employed to ascertain the degrees of valency of substances, the basicity of acids, the purity of soluble bodies; to examine the internal constitution of electrolytes, the distribution of acids and bases when together in solution; to measure the rate of chemical change in aqueous solution; to examine the chemical constitution of dissolved isomeric mixtures, &c. As an illustration of the latter two instances are given in which two mixtures possessing the same ultimate chemical composition exert very different amounts of voltaic energy.

The author states that it would be easy to indicate a very large number of mixtures which might be examined by this method, and thus lead to the discovery of probably thousands of definite compounds which exist only whilst in solution, and are decomposed on evaporating or crystallising the solutions.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 13, 1889.

The importance of dealing decisively with the question of the leakage from the gas mains here does not diminish as the subject is looked into, and it is beginning to dawn upon some of the officials interested that they have a pretty big problem to deal with. In my last letter I mentioned the recent explosions of gas in the electrical subways in this city, and stated that they had caused no little sensation. Since that time the investigation which was begun by the Board of Electrical Control has been pursued, and it develops daily new facts of interest. It appears that there are no fewer than 1,080 miles of gas mains on Manhattan Island, which have been laid down at various times, and some of which are 30 or 40 years old. From every mile of these mains more or less gas is escaping. So long as the lost gas is absorbed in the streets and in the soil under the bedway of the roads it does not do much harm, and but little notice is taken of it; when, however, the streets are turned up for any purpose, the offensive nature of the soil saturated with gas over every inch of it becomes apparent, and when it comes to the question of constructing the subways the main difficulty is found to be getting rid of the gas which, accumulating in the ducts, renders it impossible to enter the manhole until it has been pumped out by hand. The gas, moreover, is not only the cause of explosions, but is a bitter enemy of the cables which have gone through the ducts, attacking their insulation, and no matter how good and perfect they may be, seriously affecting their usefulness after a time. This week, closely following on the explosion which ruptured the subway at Twenty-third-street and Fifth-avenue, and probably rendered it more liable than ever to the accumulation of gas, a test has been made of a new cable which has been drawn in for the United States Company. This cable is now carrying 10 arc lamps, and instead of erecting new poles for them the old street gas lamps have been utilised. The test is spoken of as having proved successful in every respect, and in consequence there is great jubilation among the newspapers and the subway people. I need hardly point out that this rejoicing is a little hasty, especially in view of the fact that arc light circuits that have been tried underground before have been more or less expensive failures. However, the results six months or a year hence will show what the actual value of the test is. I may note in passing that the use of the old gas lamp posts instead of the lofty poles hitherto used for the electric light is regarded as an improvement, chiefly by the storekeepers in the vicinity, as the low lights give better illumination for their show windows and interiors.

The early coming of spring has given another fillip to the activity already existing in the electric railway field, and one hears of new projects and new roads in every direction. The Sprague, Thomson-Houston, Bentley-Knight, Daft and other companies report themselves as overcrowded with work. I heard this week that the Thomson-Houston Company were something like 250 car trucks behind their orders, and saw little prospect of catching up without an increase of their force. The popular approval of the electric railway is shown by a series of noteworthy testimonials published by the Sprague Company from the mayors of various cities in which their system is in operation. In fact, in these cities it begins to be hard to find a man who is willing to say a word against the electric railway. Among the improvements recently adopted that have added to the efficiency of operation are the carbon brushes used by the Thomson-Houston Company; and now we seem to be near the day of the motor which, like some human beings, will run better when it is wet than when it is dry. Your readers will probably recollect that in his Paper read before the American Institute of Electrical Engineers, Mr. Frank J. Sprague spoke of introducing a motor that can be washed down with a hose, and so clear all the dirt that would accumulate in a long day's run under the cars. His remarks seem to have inspired the Thomson-Houston Company, for Mr. Merle J. Wighteman this week describes some remarkable experiments made at the Lynn factory with a Thomson motor. One of the company's ordinary motors, he says, is fitted with a new waterproof armature of most recent design which, while running with a difference of potential of 500 volts at the brushes, was doused with successive pails of water. Armature, commutator, brush holders, field and connection terminals, received each a pail or two, and the motor ran as quietly under such treatment as though it were an Englishman taking his accustomed cold bath in the morning.

Prof. Elihu Thomson, who has already enriched the field of electricity by so many admirable inventions, has added to his laurels by a recent description of an apparatus, or rather by the enunciation of a new method of regulating transformers, which cannot fail to have considerable influence on the employment of this form of apparatus. Prof. Thomson's latest invention consists in so constructing the transformer that the primary may be connected to an alternating source of potential and the secondary may be made to deliver either constant current or constant potential as desired. The principle upon which the transformer is constructed is analogous to some extent to that in the method of regulation employed in the Trotter dynamo, in which a magnetic shunt around the poles of the field magnets causes the variation in the field strength, which regulates the current delivered. Prof. Thomson uses this principle in a beautiful manner, and the apparatus itself is extremely simple. The ordinary converter is merely provided with two tongues made integral with the sheets of iron, and these tongues approach each other more or less closely according to the amount or quality of regulation required. Thus it will be evident that with these two tongues part of the lines of force generated will pass through the air space between them and part through the section of iron encircled by the secondary coil. It will thus be seen that any tendency to increase in the current flowing in the primary coil, resulting from a lowering of the resistance in the circuit of the

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secondary, will be at once followed by the development of increased magnetisation of that part of the core enclosed by the primary coil by the formation of increased magnetic lines across the air space; while at the same time the self-induction of the secondary coil itself will undergo an increase, owing to the fact that a path of variable pressure for the maximum in the coil is likewise formed across the air space. In addition, the partially closed air path has an added effect due to the repulsion of the inducing magnetism in the secondary. This form of regulation is particularly adapted to the maintenance of constant current in the secondaries of transformers connected to constant potential circuits, and hence permits of arc lamps being run off them with impunity. A number of other applications of this principle will readily suggest themselves, and it would seem to open up a new field of work for the alternating current.

One of the interesting signs of the interest taken in electricity at the present time is the amount of space that our magazines are devoting to it. Last year *Scribner's Magazine* made a great hit with a series of popular articles on the American railway system and its incidental features. These articles were contributed by leading experts, and conveyed a vast amount of information in a popular and pleasant way, doing much to clear up misconceptions and to give the public a broad and liberal appreciation of the good work that has been done in the railway service. *Scribner's* now proposes to bring out this year a series of articles on the same lines, dealing with electricity. These articles will give the public an idea as to what electricity is, what it can do, and what it cannot do, and will be contributed by a number of well-known men, including Prof. C. F. Brackett, Prof. Henry Morton, and Mr. A. E. Kennelly, of the Edison Laboratory. This series of articles will be read with much interest by electricians as well as by the public, and will undoubtedly do great good. Just recently the *Century Magazine* has had an excellent article by Mr. Charles Barnard on "Something Electricity is Doing," giving a graphic sketch of the lines of development of the electric motor industry; and this month the *Cosmopolitan Magazine* comes out with an illustrated article on "Edison," giving pictures of his house, his library, and his laboratory at Orange, and some interesting details of his career and of the manner in which he pursues his daily investigations at the laboratory. Another significant instance, as revealing the general desire to know something more of electricity, was given this month by the *Century* in publishing the prospectus of its magnificent new dictionary, which is to be issued in some twenty-four monthly parts, and will contain about 6,000 quarto pages. The sample page given to illustrate the style and nature of the contents is an electrical one. The fact that electricity should be the one topic thus picked out must, I think, strike anybody as significant.

In the article on Mr. Edison just referred to some interesting details are given as to the equipment of the now famous laboratory. It appears that one section is devoted to store purposes, containing hundreds of drawers and thousands of pigeon-holes, to fill which the whole of animate and inanimate nature appears to have been laid under contribution. The collection includes everything that it is possible to mention, Mr. Edison having tried to gather together samples of every material to be found in the habitable or explorable world. The collection is, therefore, a pretty costly one, and includes thousands of substances and packages that will never be used, but it is no doubt a great convenience to Mr. Edison to have all these materials ready to his hand whenever he is carrying on any new investigation. As an example of the manner in which delay is thus avoided at critical moments, reference is made in the article to the exhaustive researches that were gone into in finding the right kind of filament for the incandescent lamp, and more lately in finding just the right kind of needle for the vibrating diaphragm of the phonograph, a needle which, of course, has to possess peculiar properties of elasticity and rigidity. It would appear from this article that at this time Mr. Edison is carrying on some interesting experiments with a view of obtaining electrotypes of phonograms, so that they may be endlessly reduplicated. It would also appear from one or two casual hints in the article that Mr. Edison is giving up a great deal of his time to work in chemistry. This is probably the case, for he has more than once lately spoken of his great interest in that branch of study. The picture of the chemical room in his laboratory shows that it is generously supplied with material and apparatus.

CORRESPONDENCE.

THE EDUCATION OF ELECTRICAL ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The number of our theoretically trained men that are being turned out yearly from our technical schools and colleges is rapidly increasing, and there is every sign of a still greater supply of one-sided electricians. It is therefore about time that some outcry was made against the misleading and rather highflown prospectuses that are constantly being sent to parents of the middle and upper middle classes regarding the short expenditure of time and the small expenditure of money required in qualifying for the profession of electrical engineering. There are several inaccuracies in these which do not escape the eye of a practical and commercial man. There is hardly any field nowadays for a man who has only spent a few months at a school where they teach the "best grouping of batteries" and other feats of mathematical gymnastics which never once in a hundred times occur in actual practice. Usually at the head of the letterpress there occurs some highly-coloured statement that anyone who has spent a short time in the laboratory will be at the expiration of the course a fully qualified electrical engineer, and will be able to command between £100 and £200 per annum. Very few well-trained men who have served a complete apprenticeship with a good firm will begin at anything like £100 per annum. It is a pity that the ministers, doctors, and lawyers into whose hands these missives should fall are so easily made to believe that their sons can be turned into trained electricians in the short space of time and at the small expense quoted by these gentlemen, and that without any workshop training or practical acquaintance with engineering. It is but useful now to mention one other point, and that is—the expression that this is "a field not yet overcrowded" may be the opinion of those who turn out book-learned electrical engineers, but it is not the opinion of those who are practically engaged in it. This one word of caution may do good in drawing attention to a state of affairs which is hardly creditable to those who have caused it.—Yours, &c.,

London, N., April 22. GERALD DAY.

GLOBULAR LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following is an account of an occurrence of "globular lightning" in Ealing between twelve and one o'clock to-day during a very severe hailstorm, as described to me by three or four eye-witnesses when I visited the spot this afternoon, and will I think be of interest.

A ball of fire "like a large football" came along the tops of the houses of St. Mark's-road; on the roof of No. 2 it dislodged several slates, a tile, and a lump of mortar weighing some 7lb. or more from the brickwork of a chimney, and then returned to the top of the road, where it burst. During its motion it is said to have rested for a moment upon a wash-house. The room just below the injured room was found to be full of smoke. I cannot gather whether its appearance was accompanied by any noise—some say not, and others that there was a clap of thunder; but I am inclined to think that a loud clap of thunder following a flash of forked lightning which occurred about the same time may account for the confusion of testimony.

All were agreed that what they called the thunderbolt was a round ball, very brilliant, and that it caused the destruction above described, which I examined for myself. Beyond this it is difficult to gather any reliable information, especially

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as to its movements, as such a phenomenon would be very likely accompanied by optical delusions due to the persistence of its impression upon the retina of the eye after the image itself had vanished.—Yours, &c.,

EDWARD W. COWAN, Assoc.M.Inst.C.E.

1, Grange-park, Ealing, April 22, 1889.

[We should be pleased to hear from any of our readers who may have witnessed this discharge.—ED. *E.*]

PHOTOGRAPHS OF LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with much interest your report of Mr. Whipple's Paper on "Lightning Photographs," and as one of those who sent a "twisted ribbon" photograph to the Meteorological Society should like to say that in my case the window was wide open and nothing intervened between the lens and the flash, so his explanation will not apply in this case at any rate. There seems to me no reason to doubt that the photograph represents the actual path of the flash—indeed, it would surely be much more remarkable if the path of least resistance were in one vertical plane, even supposing there is no deeper reason for the spiral path. It is, I think, worthy of note that in the narrative of the Greeley Arctic Expedition the aurora streamers in certain cases are described as resembling twisted ribbons.

As regards the dark flash the "photographic" explanation of over-exposure is the simplest, and appears more likely than any error from careless printing, even supposing the effect could be got in the manner suggested, which seems doubtful; and even if it were done, it would be almost impossible to get two prints identical.—Yours, &c., A. K.C.

MIRRORS FOR GALVANOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could any of your readers inform me what process is used in silvering glass to make very light mirrors for reflecting galvanometers?—Yours, &c., A. B. SMITH.

189, Maida Vale, W.,

PATENT RECORD.

APPLICATIONS FOR PATENTS.

NOTE.—*The undermentioned applications are not open to public inspection until after the acceptance of the complete specification. The names within parentheses are those of communicators of inventions.*

March 27, 1889.

5,241. P. M. JUSTICE. London. Improvements in magnets, magneto-generators, and telephones (E. M. Greene, United States).

5,251. R. KENNEDY. Glasgow. Improvements in generating and storing electric energy.

5,282. A. H. GLADWIN. London. An electric time indicator, with or without calendar.

5,293. T. H. HICKS. London. Improvements relating to apparatus for the distribution and conversion of electric currents.

March 28, 1889.

5,300. K. G. GARBE and K. ROSS. London. Improvements in making electric bell pushes by pressing xylinite, celluloid, tortoiseshell, and other materials (which by process are made pliable) into any design required.

5,322. T. J. MURDAY. London. Apparatus for obtaining readings from indicators placed at a distance by the agency of electric currents.

5,348. W. E. AYRTON and J. PERRY. London. Measuring and regulating electrical frequency and currency.

5,357. J. J. RATHBONE. London. A novel construction or arrangement of appliances for measuring or ascertaining electric energy, and for recording the voltage or ammeter of currents.

March 29, 1889.

5,377. F. KING and W. P. MENDHAM. Bristol. Improvements in electrical testing instruments.

5,391. H. ARON. Liverpool. Improvements in the method of and appliances for insulating electric wires.

5,407. A. C. COCKBURN and H. W. HANDCOCK. London. Improvements in fuses and cut-outs for electric circuits.

5,423. F. KING. London. Improvements in conduits or supports for electric conductors.

March 30, 1889.

5,509. H. E. FENNER. London. Improvements in electric arc lamps.

5,511. W. BOGGETT. London. Improvements in obtaining electricity.

April 1, 1889.

5,515. A. W. COX and WALKER AND CO. Winchester. Improvements in telegraph instruments.

5,563. H. H. LAKE. London. Improvements in electric batteries (Lacombe and Co., France).

April 2, 1889.

5,612. H. H. LAKE. London. Improvements relating to the distribution of electric currents and to apparatus therefor (E. W. Rice, jun., United States).

5,615. J. A. TIMMIS. London. Improvements in the generation of electricity on railway trains.

5,621. H. H. LAKE. London. Improvements in and relating to electric induction coils or transformers (E. Thomson, United States).

5,640. A. J. BOULT. London. Improvements in or relating to electric railway signals (W. H. Waddell, United States).

5,656. H. WELCKER. London. A novel arrangement for conducting an electric current through the nose.

April 3, 1889.

5,676. D. REID and J. KEAN. Glasgow. Improvements in electric bells.

5,730. S. JOY and W. H. JOY. London. An improved combined ampere and voltmeter.

5,738. A. W. FITCH. London. Improvements in and connected with insulators for electric light and other wires (R. O. G. Drummond, South Africa).

April 4, 1889.

5,740. J. WOOD. Blackburn. Voltaic electric belt made with zinc and copper strips united to each other, to fit any part of wearer.

5,768. W. G. DE F. GARLAND. London. Improvements in wooden casings for electrical conductors.

5,774. R. P. SELLON and A. J. SPILLER. London. Electric lamps.

5,789. D. H. DAVIES and J. M. TOURTEL. London. Improvements in apparatus for effecting by insertion of a coin the production of electric light for a certain time.

April 5, 1889.

5,816. W. E. LANGDON. Derby. Improvements in electrical accumulator or secondary batteries.

5,832. G. HOOKHAM. Birmingham. Improvements in electricity meters of the pendulum class, parts of such improvements being applicable to other kinds of electricity meters.

5,839. T. H. ALLUM, G. C. FRICKER and J. R. BAINTON. London. Improvements in dynamo electric machines.

5,844. O. J. LODGE. Liverpool. Improvements in protecting telegraph, telephone, electric lighting, and other installations and instruments from damage by lightning or other high-tension electric currents, and in apparatus therefor.

5,858. B. OLLENDORFF. London. An improved tape-winding apparatus for use with telegraph-printing machines and other instruments.

5,867. A. GRAHAM. London. Improvements in connection with switches for telephone circuits.

April 6, 1889.

5,888. A. P. TROTTER. London. Improvements in methods of measuring electric resistance.

5,904. W. M. POPPLEWELL. London. Improved means and apparatus for electrically communicating between trains and fixed points or stations (F. Lefrançois, E. Manborque, and O. Boin, France).

5,912. C. J. VAN DEPOELE. London. Improvements in systems of suspending electric conductors. [Date applied for under Section 103 of the Patents' Act, 1883, 10th September, 1888, being date of application in the United States.]

5,913. C. J. VAN DEPOELE. London. Improvements in devices for establishing electrical contact in electric railways. [Date applied for under Section 103 of the Patents' Act, 1883, 7th September, 1888, being date of application in the United States.]

April 8, 1889.

5,955. E. W. LANCASTER. Birmingham. Improved ceiling rose or connector for electrical circuits and for the suspension of electrical fittings.

5,976. A. LEYLAND. London. An improved automatic electric alarm clock.

6,005. C. J. VAN DEPOELE. Liverpool. Improvements in carbon contacts or commutator brushes. [Date applied for under Section 103 of the Patents Act, 1883, September 7, 1888, being date of application in the United States.]

6,007. M. MCMULLIN. London. Improvements in the construction of electric brushes for curative purposes.

6,021. A. L. SHEPARD. London. Improvements relating to dynamo-electric machines and electric motors.

6,027. W. J. L. HAMILTON. London. Improvements in apparatus for governing, starting, stopping or adjusting steam, hydraulic and other motors and electric installations, and for regulating water-levels, the temperature of bearings, and for other regulating purposes.

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April 9, 1889.

6,033. J. Abserdam. London. Improvements in the art of transmitting articulated speech by the agency of electricity without employing pulsatory, undulatory or vibratory electric currents on the line.

6,063. H. H. Lake. London. Improvements in and relating to safety devices for electric circuits (E. Thompson, United States).

6,064. H. H. Lake. London. Improvements relating to electro-magnets and to armatures for dynamo-electric machines or electric motors (E. Thompson, United States).

6,065. H. H. Lake. London. Improvements in and relating to electric motors (E. Thompson, United States).

6,078. F. A. Gobert. London. Improvements in electric arc lamps.

6,104. H. H. Lake. London. Improvements in the manufacture of filaments for incandescent electric lamps (J. B. Tibbits, United States).

6,112. P. A. Newton. London. Improvements in secondary batteries (W. Main, United States).

6,119. J. J. Shedlock and R. Mestern. London. Improvements in thermo-electric batteries.

April 10, 1889.

6,165. F. H. Berry. London. An improved electrical apparatus for periodically ringing bells or sounding alarms, and registering the same.

6,171. C. R. Heap. London. Improvements in means for regulating or controlling electric currents.

April 11, 1889.

6,195. G. H. Shepherd. London. Improved method of and means for constructing globes for incandescent electric lamps.

6,209. E. Liebert. London. An improved exciting liquid for use in electric batteries.

April 12, 1889.

6,231. W. E. Ayrton, J. Perry and E. W. Smith. London. Improvements in apparatus for producing electro-magnetic action with small self and mutual induction.

6,284. H. N. Prentice. London. Improvements in electric cut-outs.

6,285. H. N. Prentice. London. Improvements in dynamo-electric machines and electric motors.

6,286. D. Urquhart and W. Bates. London. Improvements in secondary batteries.

6,332. W. H. Scott and L. Paris and Scott (Limited). Norwich. Improvements in connection with electric fuses.

6,384. A. A. Goldston. London. Improvements in and relating to electric switches.

April 15, 1889.

6,410. R. A. Burnell. London. Improvements in galvanic cells for telephones (T. Wilms, Hamburg).

6,416. H. C. Nowell. Hammersmith. An improvement in electrical contact makers, or switches, or connectors, for the passage of a current of electricity.

6,423. A. J. Jarman. London. Improvements in electrical motors and apparatus connected therewith, especially applicable to purposes of locomotion.

6,429. C. Wells. London. An improved electric apparatus.

6,458. P. Hoho. London. Method of regulating the electric current produced by an electric machine driven by a motor having an irregular or variable speed.

April 16, 1889.

6,520. W. P. Thompson. Liverpool. Improvements in or relating to electrical motors for clocks and similar apparatus (G. and L. Hoppe, Germany).

6,527. H. H. Lake. London. Improvements relating to electro motor (N. Tesla, United States).

6,544. A. A. Goldston. London. Improvements relating to electric incandescence lamps.

6,547. S. C. C. Currie. London. Automatic circuit controllers for electric circuits.

April 17, 1889.

6,553. Sir W. Thomson. Glasgow. An electric energy meter.

6,557. J. N. Cooper. London. Improvements in cut-outs for electric circuits.

6,568. G. E. Dorman. Stafford. Improvements in dynamo electric generators and motors.

6,569. G. E. Dorman. Stafford. Improvements in dynamo electric generators and motors.

6,570. G. E. Dorman. Stafford. Improvements in dynamo electric generators and motors.

6,571. G. E. Dorman. Stafford. Improvements in dynamo electric generators and motors.

6,572. G. E. Dorman. Stafford. Improvements in dynamo electric generators and motors.

6,579. H. F. Jackson, A. Coleman and P. Loftus. Sheffield. A combined insulator and finial and lightning wire for telephone, telegraph, or other electric wires.

6,609. W. Boggett. London. Improved method and means for obtaining electricity.

SPECIFICATIONS PUBLISHED.

1888.

4,626. Hoepfner. Electrolytic production of metals. (Price 6d.)
4,819. Johnson. Electro-medical battery. (Price 8d.)
4,844. Thompson (Garczynski). Electric lamps. (Price 8d.)
5,640. Edmunds. Distributing, &c., electricity. (Price 8d.)
5,848. Edmunds. Electrical operations at intervals. (Price 8d.)
6,627. Tabourin. Electric lamps, &c. (Price 8d.)
6,836. Ayrton and others. Electro-dynamic relay. (Price 6d.)
7,308. Randall. Electric date, &c., stamp. (Price 8d.)
7,522. Houghton. Electric switch. (Price 8d.)
7,750. Dulait. Electric arc lamps. (Price 8d.)
2,949. Cross. Galvanic batteries. (Price 8d.)
6,382. Miller. Electric automatic delivery box. (Price 8d.)
6,876. Aron. Measuring electric currents. (Price 8d.)
7,111. Davies. Electrical couplings. (Price 8d.)
7,720. Boardman. Electric tell-tales. (Price 8d.)
7,876. Willcox (Abakanowicz and another). Electric batteries. (Price 8d.)
8,039. Le Clercq and Vansteenkiste. Generating, &c., electric currents. (Price 8d.)
9,381. Imschenetzky. Electric batteries. (Price 8d.)
12,198. Schmidt. Electrical switches. (Price 8d.)
12,817. Dixon. Electrically stopping steam engine from a distance. (Price 8d.)

1889.

485. Newton (Piédrahita). Electric generators. (Price 6d.)
3,401. Sperry. Dynamo electric machines. (Price 8d.)
3,456. Currie. Electric circuit couplers. (Price 8d.)

PATENT
SILICIUM BRONZE AND SILICIUM COPPER WIRE.
The best for overhead Telephone and Telegraph Lines,
AND ALL ELECTRICAL PURPOSES.
Hard Drawn High Conductivity Copper Wire.
ROLLED AND DRAWN
PHOSPHOR BRONZE.
PHOSPHOR BRONZE
BEARINGS, BUSHES,
AND OTHER PARTS OF
ELECTRICAL MACHINERY.
SOLE PROPRIETORS of the British, Indian and Colonial Patents,
THE PHOSPHOR BRONZE COMPANY (Limited),
87, Sumner Street, Southwark, London, S.E.
WIRE AND SHEET MILLS: BAGOT STREET, BIRMINGHAM.

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BOOKS, &c., RECEIVED.

"Munro and Jamieson's Pocket Book of Electrical Rules and Tables." Sixth edition. (London: Charles Griffin and Co.)

"Price List of Electrical Testing and other Scientific Instruments. (Westminster: Nalder Bros. and Co.)

"The Republic of Uruguay." Retrospect from "La Razon."

COMPANIES' MEETINGS & REPORTS.

The Anglo-Portuguese Telephone Company (Limited).

The following is the report of the Directors of this Company presented at the adjourned second ordinary general meeting of shareholders held at the offices of the Company, 53, New Broad-street, E.C., on Thursday, April 25, at three o'clock:—

2. After making all deductions, the profit on the year's working amounts to £4,133. 2s. 2d., making with the amount carried forward from last year the total amount of £5,827. 19s. 7d. standing at the credit of profit and loss account. This amount it is proposed to carry forward to next year's account, to be dealt with hereafter as the Board may deem advisable.

3. The capital expenditure for the year amounted to £9,709. 16s. 9d. Your Directors beg to state that it has been necessary to build a new exchange in Lisbon in consequence of the increased number of subscribers, and also to make extended switchroom accommodation in Oporto, to open up new and improved routes, as well as other works undertaken at the instance of the Government Fiscal. It is on this account that such a large outlay of capital has been incurred. Your Directors have every reason to believe that the result will in the early future repay the outlay.

4. Your Directors are pleased to report that the issue of £10,000 Six per Cent. Debentures made in May last was successful, all the bonds being at once subscribed for.

5. The number of paying subscribers at December 31 last was:—In Lisbon 912, of a gross annual value of £6,625; in Oporto 721, of a gross annual value of £3,943; total, £10,568, showing a total increase in subscribers of 210, and in value of £1,268 over the preceding year.

6. A new law having recently been enacted which your Directors consider to be at variance with the terms of the concession granted to this Company, and which may possibly become somewhat harsh and vexatious in its application, your Directors are taking such steps in Portugal as they consider necessary to protect the Company's interests.

7. Dr. Frederic Clift having ceased to be a member of the Board, and an application on behalf of the debenture-holders having been made that they should be represented, Mr. C. L. W. FitzGerald, as representing that interest, has been elected to fill the vacancy.

8. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., being eligible, offer themselves for re-election.

Great Northern Telegraph Company of Copenhagen.

The financial statement of the Company for the year 1888 is just issued, and is as follows:—

The total receipts of the Company during the year, including the balance brought forward from 1887, amounted to	£329,119	8	3
Expenses	64,440	2	10
Net profit	£264,679	5	5
Payments already made:—			
5 per cent. interest on debentures (1881 and 1883 issues)	£16,000	0	0
Amortisation of 350 debentures	35,000	0	0
	£51,000	0	0

The Directors propose to distribute the balance of £213,679. 5s. 5d. as follows:—

Reserve and renewal fund	£55,555	11	1	
Pension fund of the staff	2,777	15	7	
Remuneration to the board of directors	1,500	0	0	
Interim dividends already paid	£75,000			
Final dividend proposed, making a total of 7½ per cent	37,500			
	112,500	0	0	
Balance carried forward	41,345	18	9	
				£213,679 5 5
				£264,679 5 5

The investments during the year on account of the reserve and renewal fund amounted to £37,218. 3s. 10d. The revenue fund on the 31st December last amounted to £573,792. 1s. 11d.

At the general meeting to be held at Copenhagen on the 27th inst., the following resolutions will be proposed:—(1.) "*That the report and balance sheet be adopted, and that discharge be given to the Board of Directors.*" (2.) "*That C. St. A. Bille, Esq., be re-elected as a member of the Board of Directors.*" (3.) "*That A. Berner, Esq., and S. Bille, Esq., be re-elected as Auditors of the Company.*"

CITY NOTES, &c.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended April 12, 1889, amounted to £2,521, and for the week ended April 19, to £2,179.

CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY (LIMITED).—The annual meeting of this company was held at its offices, 101, Leadenhall-street, on Wednesday, April 17, at 12 o'clock, Sir Geo. R. Prescott, Bart., chairman of the board of directors, presiding. We learn that a most satisfactory report of the year's working was presented showing a very large increase of business during 1888, and a dividend on the ordinary shares was declared, a substantial sum being also carried forward to the reserve fund. Sir Geo. R. Prescott and Mr. Henry Drake were re-elected directors, and the proceedings, which were unanimous throughout, terminated with a cordial vote of thanks to the directors and officers of the company.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended April 12, 1889, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £1,220, and for the week ended April 19, £1,057.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The traffic receipts of this company for the half-month ended April 15, 1889, were £3,732, against £3,012 for the corresponding period last year.

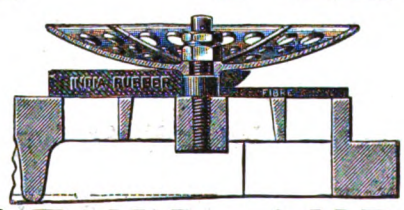
PERSONAL.—We understand that Mr. J. Swinburne has closed the lamp works at Chelmsford and gone into partnership with Earl Russell and Mr. H. S. Holt. Messrs. Swinburne and Co. have temporary premises at Teddington, and Mr. Swinburne's address for consulting work is 49, Queen's-road, Wimbledon.

——— The Telegraph Manufacturing Company (Limited) write us (confirming the announcement in our last issue) that Mr. J. Slater Lewis has resigned his position as managing director of the company, and has no longer any connection with or interest in the firm.

——— We are informed that Messrs. Dorman, Long and Co., steel and iron manufacturers, of Middlesbrough, have taken offices at 19, Victoria-street, Westminster, and that Mr. H. B. Powell will act as their representative.

NEW VALVE

No Rubber, Percha, or Leather.



One-half the price of Rubber or Metal.

FOR CIRCULATING AND AIR PUMPS.

Unaffected by any Lubricating Oils. Does not Expand in diameter. Feed Water may be worked at any temperature. Suitable for any shaped guards. Only one quality manufactured.

"12, John-street, Sunderland, 26th Sept., 1885.

"DEAR SIRS,—In reply to your letter of the 25th inst., the Valves I got from you have done their work well, and ARE AN UNQUALIFIED SUCCESS. I will continue to get them from you as required.—Yours faithfully, JAMES WESTOLL."

For further Testimony and Prices, apply to **MOSSES & MITCHELL, 68-71, Chiswell Street, London.**

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Price, Wednesday, April 24, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending April 24, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£ 1,770,360	Stock	15/0	Anglo-American	51½ 52½	3 18 5	Jan., Apr., July, Oct.	...	...
2,614,820	Stock	30/0	Do. Preferred	87 88	4 10 11	,, ,,	87⅞	87
2,614,820	Stock	...	Do. Deferred	19½ 20	...	February	20	19⅛
130,000	£10	5%	Brazilian Submarine	13½ 13¾	5 1 9	Mar., June, Oct., Dec.	13⅝	...
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
75,000	£100	3/0	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14¼ 14¾	6 2 0	February and August	...	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	1/7½	Direct Spanish (£4 paid)	3½ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States	10½ 11	4 6 4	Jan., Apr., July, Oct.	11	10⅞
380,000	10	2/6	Eastern	13¼ 13½	4 8 11	,, ,,	13½	13⅜
70,000	10	3/0	Do. 6 per Cent. Preference	14⅜ 15¼	3 18 8	,, ,,	15¼	15
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock	107 109	3 13 5	May and November.	108½	...
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	4 10 11	February & August	...	...
250,000	10	2/6	Eastern Extension xd and bonus	13¼ 13½	4 16 4	Jan., Apr., July, Oct	13½	13⅜
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	...	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	104	103½
179,177	10	1/3	Globe Telegraph and Trust	7⅜ 7⅝	4 15 1	Jan., Apr., July, Oct.	7⅝	7⅜
178,992	10	3/0	Do. 6 per Cent. Preference	14⅜ 14⅝	4 2 1	,, ,,	14⅝	14¼
150,000	10	5/0	Great Northern	15 15½	4 16 9	Jan., July, and April	15 5/16	15 3/16
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's	7¼ 7¾	5 3 2	April and October	...	...
15,609	10	3/0	West African Telegraph	7½ 8½	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 103	4 18 0	March & September	...	...
30,000	10	6/0	West Coast of America	9½ 10	5 0 0	January and July	9 1/16	...
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1¾ 2	...	...	...	...
34,563	10	12/0*	Do. 1st Preference 6%	11½ 12	...	April and October	11 15/16	11⅞
4,669	10	†	Do. 6 per Cent. 2nd Preference	12 13	...	...	...	...
45,181	15	6/0	Western Brazilian	12½ 13	5 16 3	March & September	12 13/16	12 7/16
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	100½	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	¾ ⅞	...	Yearly	...	...
220,000	£1	3%	Oriental (11s. paid)	⅜ ½	3 6 1	...	...	...
80,000	5	5/0	United	15 15½	4 16 9	June and December	16½	15 5/16
55,000	5	...	United River Plate	5⅞ 6⅛	...	January and July	6	...
			ELECTRIC LIGHT.					
23,003	5	...	Anglo-American Brush (£4 paid)	3¼ 3¾	...	...	...	...
23,692	5	nil.	Do. (fully paid)	4¼ 4¾	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2½ 3	...	...	2 1/8	2⅞
312,000	1	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42½	41½
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	17½ 18½	5 8 1	February & August	18¼	17 1/16

* Account arrears. † No dividend since May, 1880.

JABLOCHKOFF'S
DISTRIBUTION PATENT

(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

Are Proprietors of the above Patent, and Warn the Public against Infringement.

The following are Licensees:—

Anglo-American Brush Electric Light Corporation, Limited.
Crompton & Co., Limited.
S. Z. de Ferranti.—London Electric Supply Corporation, Limited.
W. T. Goolden & Co.
Hammond & Co.
Johnson & Phillips.
J. G. Statter & Co., Limited.

3, Prince's Mansions, Victoria Street, Westminster.

MANVILLE & MADGEN, *Managing Directors.*

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THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE.

No. 572.—Vol. XXII. FRIDAY, MAY 3, 1889. Price Fourpence.

NOTES.

The Board of Trade Inquiry terminated on Wednesday, having lasted eighteen days. The Inspector's report will probably be issued within a fortnight, and will be laid before the House in the usual way. If we escape a subsequent Parliamentary Inquiry we shall have much to be grateful for.

Some evidence of a rather singular character was given last week at the Board of Trade Inquiry in connection with what was termed "a provisional contract" between Messrs. Latimer Clark, Muirhead and Co. and the Westminster Electric Supply Corporation. The contractors undertake (provisionally) to equip a central station and distributing plant, "lamps and everything," at the rate of 30s. per lamp. Time was when it cost nearly as much to wire a house in good style, and now it appears that we can have our engines, and boilers, and dynamos, and underground mains thrown in. The station is designed for about 40,000 lamps of 10 candle-power. It may not be superfluous to mention that we learn further from the evidence that the provisional contract contains a clause to the effect that if the stipulated 30s. does not appear satisfactory when the work is done a fair price shall be fixed by arbitration. Here is an excellent opportunity for the Arbitration Committee of the Electrical Trades Section of the L. C. C.

The St. James' and Pall Mall Electric Light Company propose to lead the way in the establishment of Power stations in this country. They already hold a license from the Board of Trade for the distribution of electricity in the parish of St. James', Westminster, and their central station in Duke-street is now supplying current on a temporary circuit to the Salisbury Club. It is, however, the intention of the Company to erect a second station somewhere to the north of Piccadilly, which, it is given out, will be more particularly intended for the supply of motive power. It is just as well, perhaps, that an announcement of this kind should be made for the public benefit and to awaken interest in the undertaking; but the two stations will supply current to a common network, and there will be little or no technical difference between the one and the other. The three-wire system will be used.

Speaking of the three-wire system, we understand that the Hopkinson patent in this country has just passed into the hands of a company of American origin. What they mean to do with it we cannot say.

With reference to our remarks last week on the subject of Mr. Raikes' refusal to allow the Telephone Companies to transfer their licenses to a new company under the title of the Telephone Union, we are since informed that the license of the National Company, as well as that of the United, covers the whole country, and consequently that at least two of the existing undertakings might either of them assume the entire business. It happens, however, that the Articles of Association of the United Telephone Company do not permit it to acquire the business of a subsidiary company as a going concern, whereas there is nothing in the Articles of the National Company to forbid such an arrangement. On the other hand, the authorised capital of the National Company is not large enough to enable it to acquire the business both of the United and the Lancashire and Cheshire Company upon the terms agreed for the Telephone Union. At present the idea is to effect a reduction of about 16 per cent. all round, and to allow the National Company to absorb the two others upon this basis. Nothing has yet been finally settled, and it remains to be seen whether the powers of the Postmaster-General extend to a veto on these alternative proposals.

The Board of Trade edict relating to overhead wires has not yet been promulgated, though we believe that it may be expected very shortly. We have also reason to think that the conditions will be found to be of a thoroughly reasonable character, and not such as will in any way interfere with the legitimate development of the industries concerned.

In France the matter of an electrical standardising laboratory has passed beyond the stage of discussion at which it remains with us and entered that of practical operation. On the 9th of February last the *Société Internationale des Electriciens* inaugurated their central testing laboratory. A convenient site was secured in the Place St. Charles, Grenelle, in Paris, and a suitable building erected. Funds provided by the profits of the 1881 Paris Exhibition were set apart for this work, and M. de Merville appointed director of the laboratory, acting under the advice of a consultative committee of ten members. The laboratory consists of a number of rooms, each devoted to certain special standardising operations. Power is supplied by a 20 horse-power semi-portable engine, and current distributed to the various rooms from a secondary battery. In addition to these apartments there is a large hall in which special research work can be carried out. At the present moment Hertz's experi-

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ments are being repeated and verified, and we had the pleasure last week of being witness to their repetition. The director and his assistant are aided by a staff of pupils in carrying on the routine work of the laboratory. Although the laboratory is even yet hardly completely organised, a varied range of important testing work has been carried out, and the demand for its assistance daily increases. The following is a list of the various classes of instruments which up to the present have been examined and tested :—Amperemeters and voltmeters (19), electro-dynamometers (2), resistances (6), condensers (6), meters (7), standard cells (5), secondary batteries (4), insulation of cables (14), conductibility of wires (21), conductibility of carbons (4), tests of machines (7), photometric values of lamps (6), the total being about 101 various determinations. It is in contemplation to use the laboratory not only for this commercial and scientific assay work but also as a place where experimental work of a quantitative kind can be carried out, and under certain circumstances to permit investigators authorised by the committee to carry out special researches on matters of public utility, or in which the apparatus of the laboratory affords particular advantages not to be obtained elsewhere. It admits of no question that a corresponding institution should be brought into existence in England without delay, and that a highly useful career exists for it, although it will be without doubt limited in the first instance, and wisely so, to the standardising and checking of instruments.

THE Telegraph Construction and Maintenance Company's ss. "Scotia" on the evening of April 30 completed the Mossamedes Cape Town cable. The northern sections having been previously laid by the India Rubber and Gutta Percha Company's ss. "Silvertown," this affords a direct alternative line of submarine telegraphic communication between England and the Cape of Good Hope. The whole of these cables—over 1,900 miles in length—have been laid by the two companies named without a single hitch.

IN his Paper on Secondary Batteries (read before the Society of Arts on Wednesday last), Mr. PREECE very truly remarks that "the character and quality of the electrolyte used in secondary batteries has hitherto scarcely received the attention it deserves." But during the last twelve months Mr. PREECE has himself been working in this direction, and he is now able definitely to confirm the statement, first made by Mr. BARBER-STARKEY in 1886, as to the value of sulphate of sodium as an addition to the ordinary sulphuric acid solution. Mr. PREECE has further determined the relative quantity of the salt which gives the best result, and in future he intends always to use this particular solution. Probably the majority of users of secondary batteries will be glad to follow his example. The text of the Paper will be found on another page.

THERE was a crowded audience on Thursday evening at the Institution of Electrical Engineers to hear Dr. LODGE "On Lightning, Lightning Conductors, and Lightning Protectors." Although this was the first occasion on which the Institution, as a body, has had an opportunity of witnessing the experiments of "the impulsive rush" and the oscillatory discharge, the leading features of Dr. LODGE's doctrine were probably already familiar to the majority of those present. One experiment of great beauty was, however, shown for the first time; this consisted in taking a long flash from the under surface of a metallic vessel having a perforated bottom, and filled with water so as to imitate a rain shower. It was then seen that at times the spark would split up into multitudinous branches, ramifying amongst the drops precisely as we see it in many lightning photographs. (*See*, for a particularly good example, a photograph reproduced in *The Electrician* of September 7, 1888, p. 556.) It will be remembered that at Bath it was suggested that this phenomenon was due to the actinic action of the lightning flash precipitating electric discharges in places where the dielectric was already strained, in the manner then lately discovered. It would be interesting to know whether this explanation is compatible with Dr. LODGE's recent experiment. The experiments with a gas jet were also new, and were highly suggestive in character.

IT is understood that the discussion on Dr. LODGE's Paper will be opened by Mr. PREECE, whose vigorous defence at Bath of the report of the Lightning Rod Conference will be fresh in the memory of our readers. (If not, they may look it up in *The Electrician* of September 21st and 28th, 1888). It appears to us, however, that Mr. PREECE will find it a task of increasing difficulty to maintain the position which he then took up. At that time it was admitted that the magnetisation of steel by the lightning flash was difficult to reconcile with the alleged oscillatory character of the discharge. Thanks to Prof. EWING (*The Electrician*, October 5, 1888, p. 712), that difficulty has now been removed. The doctrine of electrical oscillations is now so solidly established, and is so abundantly confirmed, that if Mr. PREECE still disputes its application to the lightning flash it must rest with him to show the reason why, and to show, moreover, how observed phenomena—such as side flashes, &c.—are to be otherwise explained.

AT Bath Dr. LODGE had to forego the advantage of displaying the experiments upon which his conclusions are based; but now that the Electrical Engineers have actually seen a point struck by a disruptive discharge, it will be difficult to make much capital out of the assertion that "no one has actually seen a lightning conductor struck by lightning." There is, moreover, evidence to the contrary. On July 10th, 1843, Prof. FRINK saw the conductor upon the summit of the spire of Strasburg Cathedral repeatedly struck by lightning—"stroke after stroke" (Dr. SESTIER, *La Foudre*, Vol. II., p. 451). This is only one out of a dozen similar instances recorded in the volume from which we quote. Is it possible that the Lightning Rod Conference were unacquainted with the invaluable record of facts (mingled, doubtless, with some fables) relating to thunderstorms, collected by SESTIER, and published at Paris in 1866? We should like to see an English translation of this

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treatise, which affords a perfect mine of wealth for the illustration of the subject.

THE process of "pickling" sheet iron in the tin-plate manufacture, and the possibility of effecting a saving of material by the aid of electricity, has long afforded an interesting field for the researches of the electro-metallurgist, as well as a profitable source of revenue for the Patent Office. Though the actual quantity of material wasted per plate in the process of removing the rust from the surface of the iron by sulphuric acid is very small, yet, owing to the gigantic development of the industry, it represents many thousand tons of iron per annum. All sorts of devices have been patented for recovering the metal from the spent liquid, for removing the rust by electrolytic action, and avoiding loss by the transfer of a thin layer of the metal underneath from one plate to the other, and even for depositing a film of iron on the outside of a plate already coated with a film of the black oxide; but, at any rate until quite recently, all these efforts have resulted in failure. Some degree of success has, however, apparently attended the efforts of Mr. J. GUTENSOHN, who has for some time past been carrying out experiments upon a rather large scale at the Glarryrafron Iron Works, Clydach, near Swansea. It is claimed that the combined saving of metal and of acid effected by the process is sufficient to pay the entire charge on the electrical equipment, and to leave a balance of profit to the maker. Moreover, it reduces the amount of waste acid to be got rid of, which in itself is no small advantage. We sincerely trust that all that is claimed for Mr. GUTENSOHN'S process will be realised in practice. We may, however, remark that from certain figures which have come into our possession it would appear that electricity is only called upon to play a subordinate part in the operation; at any rate, the electrical energy actually employed appears to fall considerably short of what would be required to effect the operation by electrolysis pure and simple.

MORE reasons than one may be easily suggested for the failure of the Elieson Company to obtain a single bid for its patent rights. But apart from all other considerations, surely clause 10 of the conditions of sale was well calculated to cool the ardour of any would-be purchaser. It is therein stipulated that "if from any cause the vendors shall be unable to procure an assignment or transfer from C. P. ELIESON of any of the patents now in his name, the purchasers thereof shall be satisfied with and will accept an assignment of the beneficial interest therein, without requiring any assignment from the said C. P. ELIESON." Mr. ELIESON now asks us to state in justice to himself that he would have been glad to do anything to facilitate the sale, but that he was never even approached on the subject. The history of the Elieson Company has been an unhappy one from beginning to end. Although we have never been able to regard this system as the *beau ideal* of electric traction, yet the experience gained upon the North London lines was sufficient to show that under reasonably good management it would have resulted in a practical success. But, as with many other promising schemes in this country, technical considerations were over-ridden by the haste and greed of the commercial element, and failure is the result.

The Recent Thunderstorms.—The thunderstorms which have occurred in various parts of the kingdom within the last few days have resulted in several deaths from lightning.

St. James's Vestry.—At a meeting of this vestry last week formal permission was given to the laying of mains in certain streets by the St. James's and Pall-Mall Electric Light Company.

Newington Vestry.—At a meeting of this vestry last week it was decided to offer no objection to an application of the London Electric Supply Corporation (Limited) for a Provisional Order to supply electricity within the parish.

Institution of Electrical Engineers.—The Secretary of the Institution of Electrical Engineers informs us that the President and Lady Thomson intend to hold a *conversazione* for members of the Institution on Friday the 24th inst.

Inner Temple.—Since the abandonment of the large scheme which was being carried out by Mr. Sennett it has been decided to modify the existing installation, and the contract has been given to Messrs. Drake and Gorham, who formerly had this installation in hand.

Camera Club.—We are requested to mention that the third of the series of One-Man Photographic Exhibitions at the Camera Club will be opened on and after Tuesday, May 7, to visitors on presentation of card at 21, Bedford-street, W.C. The exhibition will continue for about two months.

Newington Vestry.—At a meeting of this Vestry last week it was formally moved: "That no objection be offered to the draft Provisional Order lodged by the London Electric Supply Corporation, or any action taken to watch the progress of the order through Parliament." The motion was carried.

The Royal Society.—The following Paper was read yesterday afternoon at the Royal Society, by Prof. J. J. Thomson, F.R.S., on "The Effect produced by Conductors in the neighbourhood of a Wire on the Rate of Propagation of Electrical Disturbances along it, with a determination of this Rate."

Folkestone.—The directors of the Folkestone Gas Company have refused to comply with the request of the Electric Lighting Committee that they should give up the lighting of the public lamps in the western part of the town, nor will they assent to any modification of or departure from the existing arrangement.

Electric Lighting Tenders.—The Streets Committee of the City Commissioners of Sewers will meet in the Guildhall on May 10th to receive the electric lighting tenders for the City. Further details will be found in our advertisement columns. Tenders are also wanted for a complete installation at Castle Mona Pavilion, Douglas, Isle of Man.

Presentation to Mr. J. D. Miller.—At the conclusion of a course of lectures on technical telephony, delivered during the winter by Mr. J. D. Miller, manager of the Dundee District of the National Telephone Company, to the male *employés* of the company, he was presented by them with a complete edition of the Waverley Novels and with a scientific work of reference.

Messrs. W. H. Willcox and Co.'s Catalogue.—We have recently received a very complete catalogue from Messrs. W. H. Willcox and Co., the well known oil refiners. Among the numerous varieties of lubricants we notice a moderately-priced dynamo oil and a special oil for gas engines. Messrs. W. H. Willcox and Co. claim that their lubricants are entirely free from the injurious acids so frequently met with in oils of the cheap and nasty type.

Chelmsford.—The Chelmsford Town Council have accepted the tender of Crompton and Co. (Limited) to light the public thoroughfares of the borough for five years with 18 arc lamps of 1,000 candle-power each and 200 incandescent lamps of 32 candle-power each, at a total inclusive cost of £873. 6s. 8d. per annum. The Council have, moreover, granted the company the exclusive privilege of lighting private houses in the borough by electricity during the term covered by the public lighting contract.

Battersea Vestry.—At a meeting of the Vestry last week attention was drawn to the great development of electric lighting, and the opinion was expressed that at the proposed Battersea Polytechnic arrangements could be made for lighting

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the parish with electricity, and thus saving some £4,000 per annum. It was also proposed that an engine and dynamo should be fitted at the dust destructor for lighting the parish stables. Both proposals were referred to the Works Committee.

Copper.—The visible stock of copper, for the first time since December, 1887, has ceased to increase. According to Messrs. Merton and Co.'s monthly statistics the stock in England, France and afloat from Chili and Australia is 124,447 tons, a decrease of 429 tons for the month of April. The deliveries are 8,509 tons, being the largest of any month's record since 1887, and the price is lower than at any time included in modern records. The long lane has come to an end, but stocks are still enormous, engagements to buy are onerous, and altogether the market carries a heavy burden uphill.

Society of Arts.—The Papers set down for the ordinary meetings of this Society on Wednesday evenings after Easter are:—May 1, on "Secondary Batteries," by Mr. W. H. Preece, F.R.S.; May 8, "Origin and Manufacture of Playing Cards," by Mr. George Clulow; May 15, on "The Use of Spirit as an Agent in Prime Movers," by Mr. A. F. Yarrow; May 22, on "Automatic Selling Machines," by Mr. J. G. Lorrain; and May 29, on "The Science of Ventilation, as Applied to the Interior of Buildings," by Mr. D. G. Hoey. Mr. H. Graham Harris will commence his course of four Cantor Lectures on "Heat Engines other than Steam," on Monday evening, May 6.

Royal Institution.—At the annual meeting of the Royal Institution, held on Wednesday last week, the annual report of the Committee of Visitors for the year 1888 was read and adopted. The real and funded property now amounts to above £81,000, entirely derived from the contributions and donations of the members; 45 new members were elected, and 64 lectures and 19 evening discourses were delivered in 1888. The total number of volumes added to the library in the year was 866. The following gentlemen were unanimously elected as officers for the ensuing year:—President, the Duke of Northumberland, K.G.; Treasurer, Henry Pollock, Esq.; Secretary, Sir Frederick Bramwell, Bart., F.R.S.

Telegraph Company Amalgamation in the States.—The *Scientific American* states that the South Atlantic Telegraph Company, of Baltimore, Md., has been incorporated with a capital stock of $50,000. The new company is to form a link in the Mackay-Bennett and Postal Telegraph Cable Company system, and is for the purpose of purchasing and owning the lines of that system in Maryland, which are now only leased. The scheme embraces an amalgamation with the Southern Telegraph Company of Virginia, the Southern Telegraph Company of North Carolina, and the Southern Atlantic Telegraph Company, whereby lines of wire may be secured extending to New Orleans and covering the entire South and Southwest. This entire system is to be controlled by the Mackay-Bennett management.

Barnet.—At last week's meeting of the Barnet Local Board the Lighting Committee reported as follows:—"In reference to Mr. Joel's account for lighting, your Committee were of opinion that the allowance of £1. 1s. 6d. off the total amount of the bill of £95. 17s. was not sufficient. They calculated that as shown by the report of the expert who tested the lights there was a deficiency of candle-power amounting to about $\frac{1}{16}$, and after discussing the matter it was agreed by your Committee that this was the proper proportion to be taken off the lighting account. On this being pointed out to Mr. Joel he agreed to accept the sum of £90 in discharge of his account, thus allowing a reduction of £5. 17s. to the Board. Your Committee, under these circumstances, recommend that Mr. Joel's account be paid. Mr. Joel promised to see that the oil lamps at the junctions of the several streets were improved." The report was adopted.

Electric Apparatus Company's Catalogue.—The fifth edition of this Company's catalogue has been materially increased in size, and now forms a profusely-illustrated and well-arranged publication of some seventy pages. A few pages at the beginning are devoted to general hints as to the meaning of electrical terms, instructions for bell-fixing, &c. We notice, by-the-bye, on page 7, the following statement:—Current = ampere = volt × ohm.," which is, we suppose, a misprint. Some thirty pages are occupied with the prices and descriptions of a large variety of bells, batteries, pushes, fire and burglar alarms; quotations are also given for electric billiard-markers and electric water-level indicators. Prices are given of several types of influence machines, including the latest form of the Wimshurst. The last fifteen pages are devoted to electro-medical apparatus of the usual character. This catalogue is very complete as regards minor electrical apparatus, and the prices quoted seem in general to be very moderate.

Telegraphs and Telephones in Uruguay.—From a pamphlet issued by the Uruguayan Consul we extract the following information:—In 1887 there were the following telegraph lines in the Republic of Uruguay:—

	kilometres.
River Plate Company	233
,, (Cable) Company	160
Platino Brasilero Company	829
Oriental Company	636
Central Uruguay Railway Company (property)	315
	2,173

In 1888 the following lines were laid out:—

	kilometres.
National Telegraphs	942
,, (Cable)	11
The "International"	222
,, ,, (Cable)	47
North-Eastern Railway (property)	123
North-Western ,, ,,	177
	1,522

There are, therefore, 3,695 kilometres of telegraph wires, by means of which all parts of the Republic are in direct communication with each other. The Province of Santa Fé has 2,600 kilometres, 712 having been laid out last year, and in the Province of Buenos Ayres there are 6,636 kilometres, of which 173 were also completed last year. In 1887 the Compañia Platino Brasilera forwarded 36,642 private messages, that brought in $45,847; 3,539 press messages, $2,726; and 2,972 official messages, $9,136. In 1888 the company transmitted 42,088 private messages, yielding $48,118; 1,941 for the press, $1,997; and 2,765 official messages, $7,143. The two telephonic companies at Monte Video have the following number of lines and subscribers:—The "Uruguaya," late the "Gower-Bell" Company, has 1,796 subscribers and as many wires. The average of daily communications is 6,000. The Co-operative Telephone Company, although only recently formed, has already placed 105 instruments and laid out 430 wires, which are not all in working order on account of the scarcity of apparatus. Taking the population of Monte Video at 140,000, and the subscribers being 2,226, the proportion is 159 subscribers per 10,000 inhabitants, whereas in Berlin it is only 48, in Paris 21, and even in Buenos Ayres 65. We have more than double the number of telephones than Madrid, with a population of 398,000, more than three times than Lyons with 402,000 inhabitants, and almost six times as many as Marseilles.

Obituary.—The death is announced of Mr. Robert Stirling Newall, D.C.L., F.R.S., F.R.A.S., J.P., of Ferndene, Gateshead, whose name is well known in connection with the invention and manufacture of wire rope. Born in Dundee in 1812, of an old and respectable Scotch family, he entered a mercantile office, and afterwards came to London, where his talents found more congenial employment under the late Mr. Robert M'Calmont, in connection with experiments on the rapid production of steam. In 1840 Mr. Newall took out a patent for making wire rope; it was this invention that made submarine telegraphy possible. He established works at Gateshead, and his firm manufactured and laid the Dover and Calais cable in 1850, the Holyhead and Howth and Port Patrick in 1852, and the Dover and Ostend, the Frith of Forth, and the Holland cables in 1853. The Black Sea cable was laid by Mr. Newall in 1855, and the Red Sea cable in 1859. After laying the latter Mr. Newall was wrecked in the "Alma," when his courage and coolness proved of the greatest help to the shipwrecked passengers, He devoted much of his time to scientific work. He was twice Mayor of Gateshead, and he was unani-

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mously asked to be mayor again this year, when the British Association visit Newcastle.

An Electric Railway Problem.—The Thomson-Houston Electric Company write from Boston as follows:—"We have just had to deal with a very peculiar problem which has arisen in the construction of one of our roads, the Cambridge Division of the West End Street Railway, Boston, Mass. It is illustrative of the mechanism used between the drawbridge and the main bridge, over which the cars are obliged to pass. It consists of two pairs of trusses, one at each end of the drawbridge, and one on the bridge adjacent, which suspend the overhead conductors, and at the end of which suspension are placed frogs, which come together in such a way when the draw is closed that the trolley cannot possibly jump the wire in passing from the conductor on the main bridge to that on the drawbridge. The overhead circuit and the circuit through the rails is completed by an armoured cable running underneath the bridge from side to side. The conductors on the bridge are supplied with current by an auxiliary cable which runs to the automatic switch, one-half of which is on the stationary portion of the pier and the other half on the movable portion of the draw. The connection at the switch is broken when the draw is open, as it is not necessary to have the current on the drawbridge, and is automatically closed when the draw swings in, so that the current can reach the overhead wires. This device has worked admirably since it was put down, and reflects a great deal upon the skill of the company's engineer who has charge of this construction work."

The City and Guilds Institute.—Lord Selborne presided on Tuesday at Mercers' Hall, Cheapside, over the annual general meeting of the governors of the City and Guilds Institute for the Advancement of Technical Education. In moving the adoption of the report the Earl of Selborne stated that there had been a decrease of 107 in the number of students attending the Central Institute compared with the previous year, but the decrease was more apparent than real. The progress made in the main work of the Central Institute had been very satisfactory, remembering that it was only opened in July, 1885. He thought it very satisfactory that in the great centres of commerce the operations of the Institute were evidently stimulating kindred operations. Referring to the technological examinations, he stated that they had always been, from a pecuniary point of view, a subject of some anxiety. The examinations really tended to regulate the instruction given throughout the country in all matters which came within the province of technical education, and their importance could not possibly be doubted. It might become necessary, as time went on and the examinations increased, for the local bodies where they took place to contribute to the expenses in connection with them. In 1888 the total number of students preparing for the technological examinations was 10,404; in the present year the number was 11,734. In 1887 the number of the classes was 365, in 1888 it was 473, and this year it was 505; and the towns in which the classes were held numbered in the present year 133. The examinations last year were in 49 subjects and in 240 centres. They had suffered a reduction of £4,000 a-year in their income from the separation from them of the Drapers' Company, from whom in the past they had received most generous support, and who they hoped would after the lapse of some time return to them. Valuable assistance had been received from the Fishmongers', the Clothworkers', the Skinners', and the Weavers' Companies, and the Institute had also received several donations in the shape of scholarships. In 1888 the subscriptions and donations received by them amounted to £24,960, but for the present year, he regretted to say, they could only reckon upon £22,495. The votes made, independently of the fees, came to £22,385 for the current year. Although fully appreciating the generosity of many of the companies, he really thought that the magnitude and importance of the work in hand were such that it ought not to be allowed to languish. Everything in connection with the Institute was encouraging, excepting the one matter of money. He hoped that they would receive greater support from the Corporation. The council claimed the credit of having given a notable impulse to the whole movement for technical education in London and elsewhere.

The Royal Society Selected Candidates. — Amongst the fifteen candidates recently selected by the Council of the Royal Society to be recommended for election into the Society the four gentlemen named below have distinguished themselves in electrical science:—

ALFRED BARNARD BASSET, M.A., barrister-at-law. Author of a treatise on Hydrodynamics, in two volumes (1888); also Papers in the *Quart. Journ. Math.*, *Mess. of Math.*, *Phil. Mag.*, *Proc.* Lond. Math. Soc., *Proc.* Camb. Phil. Soc., *Phil. Trans.* Roy. Soc. (1888), and *Amer. Journ. Math.* These Papers treat of the Motion of Liquids about Elliptic Cylinders, of Associated Functions and Spherical Harmonics, of Electric Currents of a Sheet rotating in a Field of Magnetic Force, the Potential of a Spherical Bowl, Motion of a Liquid Ellipsoid and Stability of this Motion, Motion of two Spheres in a Liquid, Potentials of Circular Disks, Motion of a Ring in a Liquid, Motion of a Sphere in a Viscous Liquid, and the Steady Motion of an Annular Mass of Rotating Liquid.

LATIMER CLARK, C.E., F.R.A.S., F.R.G.S., Electrical Engineer. Past President of the Institution of Electrical Engineers. Author of:—"Description of the Britannia and Conway Tubular Bridges;" chapter on "Tides of the Menai Straits," in E. Clark's book on the Britannia and Conway Bridges; "Elementary Treatise on Electrical Measurement;" and (jointly with R. Sabine) "Electrical Tables and Formulæ." Author of various Papers on Electric Measurement, and on various branches of Engineering Science, published in Report of the Brit. Assoc., the Government Report on Submarine Cables, and the Engineering Journals. Introduced a standard voltaic cell of great importance and value for promoting accurate measurement of electric potentials, and presented a Paper on this subject to the Royal Society, which was read June 19, 1873. From 1848-51 was Resident Assistant Engineer at the Britannia Tubular Bridge, under the late Robert Stephenson. In 1851 became Engineer to the Electric and International Telegraph Company, and remained in this service for twenty years, part of the time as Engineer-in-Chief. Made important observations on the passage of electricity through long underground lines, of which the results were the subject of Faraday's Bakerian lecture of 1854, and are given in his "Experimental Researches," with Faraday's own experiments and theory. In 1854 introduced the system of transmitting messages through "pneumatic despatch tubes" in the Electric Telegraph Company's service. The system is continued in the Postal Telegraph system of the Government, having been found admirably successful and useful.

CHARLES TODD, M.A. (Cambridge), C.M.G., F.R.A.S. Postmaster-General, Superintendent of Telegraphs, and Government Astronomer. He has executed important astronomical observations extending over thirty-eight years, including Transit of Venus, Jupiter's Satellites, Determinaton of Australian Longiudes, &c. He has conducted Meteorological Observations in South Australia, extending over thirty years. He has written a Treatise on the Meteorology of South Australia, and other works. He has contributed Papers to the Royal Society of South Australia, and was responsible for the erection of the telegraph line across the interior of Australia from Adelaide to Port Darwen, 2,000 miles in length, and to Western Australia, 1,000 miles in length.

HERBERT TOMLINSON, B.A. (Oxford), formerly Junior Student of Christ Church, Oxford; Whitworth Exhibitioner, 1870; Demonstrator of Natural Philosophy in King's College, London; author of numerous Papers on physical subjects published in *Phil. Trans.*, *Proc.* Roy. Soc., *Phil. Mag.*, &c., the most important of which relate to the influence of stress and strain on the Physical Properties of Matter. The following may be enumerated:—(1) "Effect of Magnetisation on the Electrical Conductivity of Iron" (*Proc.* Roy. Soc., 1875); (2) "Increase in resistance to the passage of an Electrical Current produced in certain wires by Stretching" (*ibid.*, 1887); (3) "Alteration of Thermal Conductivity of Iron and Steel caused by Magnetism" (*ibid.*, 1878). The following Papers relate to the influence of Stress and Strain, &c.:—(4) "Moduli of Elasticity" (*Phil. Trans.*, 1883); (5) "Electrical Conductivity" (*ibid.*); (6) "Relations between Moduli of Elasticity, Thermal Capacity, and other Physical Constants" (*Proc.* Roy. Soc., 1885); (7) "Alteration of the Electrical Conductivity of Cobalt, &c., by Longitudinal Traction" (*Proc.* Roy. Soc., 1885); (8) "Internal Friction of Metals" (*Phil. Trans.*, 1886); (9) "Coefficient of Viscosity of Air" (*ibid.*); (10) "On Certain Sources of Error in Connection with Experiments on Torsional Vibrations" (*Phil. Mag.*, 1885); (11) "Temporary and Permanent Effects on some of the Physical Properties of Iron produced by raising the Temperature to 100° C." (*ibid.*, 1886); (12) "Effect of Change of Temperature on the Internal Friction and Torsional Elasticity of Metals" (Abstract in *Proc.* Roy. Soc., 1886); (13) "Effect on Magnetisation on the Elasticity and the Internal Friction of Metals" (*Phil. Trans.*, Vol. CLXXIX., p. 1); and other Papers.

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THE USE OF THE INTEGRAPH IN DETERMINING SOME PROBLEMS IN ELECTRO-DYNAMICS.

BY L. B. ATKINSON.

(Continued from page 703.)

In the case of two electric circuits each having a coefficient of self-induction and a coefficient of mutual induction between them the equations are of similar form to equation (1), but the equation for each circuit includes a term depending on the rate of change of the current in the other circuit.

Calling E and $E_{,}$, C and $C_{,}$, R and $R_{,}$, L and $L_{,}$ the corresponding coefficients for the two circuits, and M the coefficient of mutual induction, the equations are

$$L\frac{dc}{dt}+CR-M\frac{dc_{,}}{dt}=E \text{ for the primary,}$$

$$L_{,}\frac{dc_{,}}{dt}+C_{,}R-M\frac{dc}{dt}=0 \text{ for the secondary,}$$

where $M\frac{dc}{dt}$ is, of course, the value of $E_{,}$.

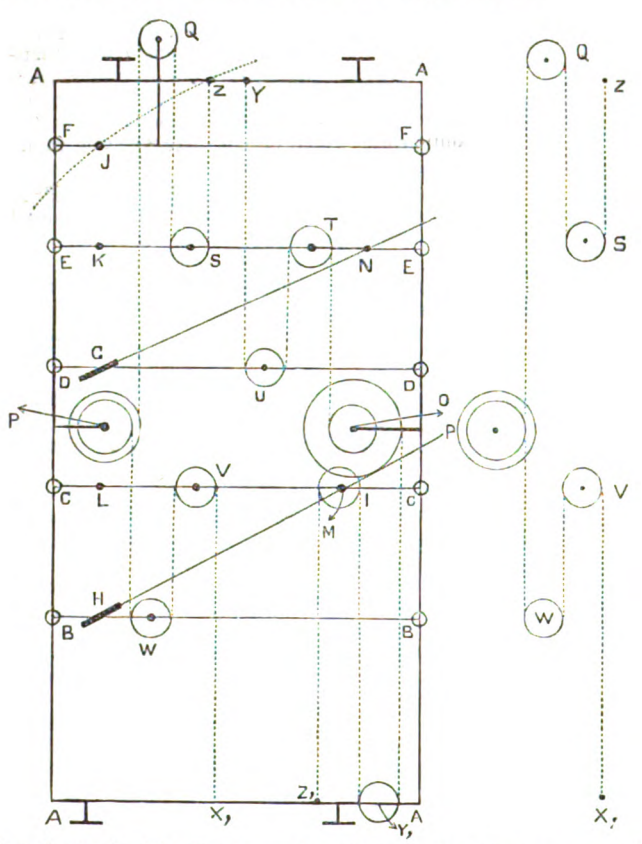
These equations may be written

$$L\frac{dc}{dt}+CR=E+M\frac{dc_{,}}{dt},$$

and

$$L_{,}\frac{dc_{,}}{dt}+C_{,}R=M\frac{dc}{dt},$$

when it is obvious that they are similar in form, and therefore may be dealt with by an integraph on a similar principle to that described for use in the case of a single circuit.



FIGS. 4 AND 6.—The Roman capital letters on the figures correspond to the italic letters in the text.

The problem now is to construct an integraph to mechanically draw the curves showing the relations between C and t, $E_{,}$ and t, $C_{,}$ and t, when the only curve given is that expressing the relation of E and t, the constants of the circuits being also given.

Proceeding as before by an analytical process, the skeleton construction of such an integraph will first be described; it will then be shown that the curves traced correspond to those defined by the above equations.

Fig. 4 is a skeleton drawing of the integraph, $a\,a\,a\,a$ is a frame supported and moving on guides or rollers parallel to the axis O X. In this frame are five cross slides $b\,b$, $c\,c$, $d\,d$, $e\,e$, $f\,f$, capable of moving parallel to the axis O Y; f carries at j a tracing point which follows the given curve of impressed E.M.F., e carries at k a point which traces the resultant E.M.F. in the primary, d carries at g an integrating wheel pivotted and guided by the rod $g\,n$ in the manner previously described, following the curve of primary current, c carries at l a tracer, which draws the curve of induced E.M.F. in the secondary, l carries an integrating wheel which follows the curve of secondary current. The sliding rods f and e are connected round rollers by a cord fixed to the frame at z and wound on a roller p. Another roller on the same axis carries a cord passing round rollers on the sliders b, c, and fixed to the frame at $x_{,}$. A similar set of cords and rollers embraces the pair $d\,e$, through the rollers on the axis O, and embraces the slider c and the fixed frame at $z_{,}$.

Fig 5 shows the geometry of the integrating mechanisms.

Fig. 6 shows one system of cords and pulleys dissociated from the rest of the mechanism in order to show its function, as follows. The points z and x being fixed, and the radii of the larger and smaller rollers at p being r and $r_{,}$, any variation λ in the distance between s and q is accompanied by a variation $\lambda_{,}=\frac{\lambda r}{r_{,}}$ in the distance between w and v, whilst at the same time w and v as a pair, or s and q as a pair, can move up or down, each pair independently of the other pair. Similarly, in Fig. 4 any variation in the distance $u\,t$ is accompanied by a variation in the distance $z_{,}\,i$ in inverse ratio to the diameters of the rollers at O. Springs, not shown in the diagram, keep these cords always tight.

It may now be shown that the double integrating system with connecting cords as described, fulfils the required conditions.

The setting of the points n and m are such that

$$k\,n=\frac{L}{R} \text{ and } l\,m=\frac{L_{,}}{R_{,}},$$

and the radii of the rollers on p are in the ratio $\frac{L_{,}}{R_{,}}:\frac{M}{R}$,

the radii of the rollers on A O being in the ratio $\frac{L}{R}:\frac{M}{R_{,}}$,

and the movements of the several cords attached to the rollers are inversely as these ratios.

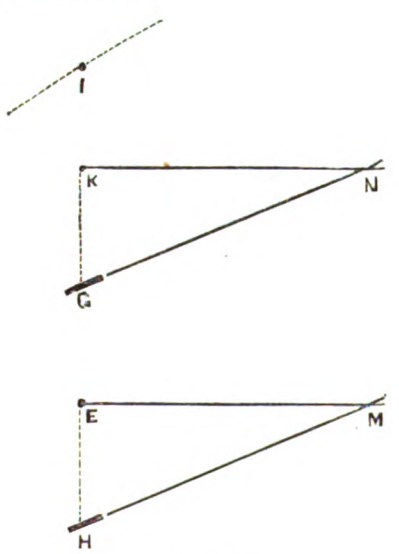


FIG. 5.

The positions and movements of the parts may be analysed as follows:—The point j follows the curve of impressed E.M.F. (drawn to a scale such that $e=\frac{E}{R}$). The point R moves thus, the co-ordinates being $E_{,}$ and t:—

$E_{,}=e+(s\,q-\lambda)$, where λ is a constant depending on the initial length of the cord,

$$=e+\frac{M}{R}\frac{R_{,}}{L_{,}}w\,v,$$

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and $w\,v = (z_1 i - \mu)$ where μ is a constant depending on the initial length of the cord

$$= \frac{L_1}{R_1}\frac{dc_1}{dt},$$

c_1 and t being the co-ordinates of the point (v);

hence $$E_r = e + \frac{M}{R}\frac{dc_1}{dt},$$

which is the resultant inducing E.M.F. in the primary, divided by the resistance R.

The integrating roller (as has been previously shown) follows the curve—

$$\frac{dc}{dt} = \frac{\left(e + \frac{M}{R}\frac{dc_1}{dt}\right) - C}{\frac{L}{R}} = \frac{\frac{E}{R} + \frac{M}{R}\frac{dc_1}{dt} - C}{\frac{L}{C}},$$

which, being re-written, gives

$$L\frac{dc}{dt} + C\,R = E + M\frac{dc_1}{dt},$$

the curve of primary current.

The point v traces (under the control of the cord $z\,i$ and pulleys on O) a curve, the co-ordinate of which,

$$e_1 = \frac{E_1}{R_1} = z\,i - \mu = \frac{M}{R_1}\frac{R}{L}gk = \frac{M}{R_1}\frac{dc}{dt},$$

which is the induced E.M.F. in the secondary divided by R_1; and, finally, the integrating roller w follows the curve (as before shown).

$$\frac{dc_1}{dt} = \frac{e_1 - C}{\frac{L_1}{R_1}} = \frac{\frac{M}{R_1}\frac{dc}{dt} - C_1}{\frac{L_1}{R_1}},$$

which re-written is

$$L\frac{dc_1}{dt} + C_1 R_1 = M\frac{dc}{dt},$$ the curve of secondary current.

It may be noted that the particular connecting mechanism between the two integrating systems here described is only suggestive: other and possibly better ones could be adopted. The brief description here given suffices, however, to show the possibility of constructing an integraph to completely exhibit the variation of E.M.F.'s and currents in two circuits under any assumed law of impressed E.M.F. In a further short article the writer proposes to show some further uses to which this class of integraph can be put in solving problems of electrical calculation.

(To be continued.)

THE INSTITUTION OF ELECTRICAL ENGINEERS.

"On Lightning, Lightning Conductors, and Lightning Protectors."*

BY DR. OLIVER LODGE, F.R.S.

Introduction.

About this time last year I delivered two lectures to the Society of Arts on the subject of "Lightning Conductors," in pursuance of a bequest made to the Society in memory of the late Dr. Mann. In those lectures I abstained, as far as possible, from practical recipes, and from anything like authoritative advice, contenting myself with calling attention to certain aspects of the subject which had been overlooked. I ventured to imply that none of the older electricians had any notion of the real conditions of the problem; that they all, from Franklin to Faraday, and down to the present day, treated it as a much easier matter than, in fact, it is, and that there had been very little real progress in this particular department since the time of Franklin.

Recent advances in electrical theory made it easy for me to see further into the matter than the far greater men of the past had had any chance of doing; and a few very simple and easy experiments soon brought the conditions of the problem clearly before me.

It was these conditions upon which I laid emphasis in my lectures to the Society of Arts. Any practical outcome I left to a later period, and very likely to other hands. The first requisite seemed to be to grasp the conditions of the problem as illuminated by theory; the second, to carry out practical reform in the light of a large experience.

Such few practical recipes as I did surreptitiously introduce I fully expected to hear criticised, nor did I lay any stress on them at the time. (I may say, however, that I have seen no occasion since to modify any of them, and that my position in respect of these practical hints is stronger now than it was then, inasmuch as I find that the large experience of the Belgian electricians, who have given more attention to this subject than perhaps any other school, has led them to recommend in recent years almost precisely the same methods of protection as those I advocated, their views being acquired almost entirely by practical experience and scarcely at all by theory.)

The theoretical and experimental portions of my lectures were, however, matter of serious consideration with me, and nothing was set down under these heads but that of which I was absolutely sure. These portions have by all pure physicists been, so far as I know, universally accepted; as, indeed, they contain nothing but what any one of them could have easily arrived at had he happened to give sufficient thought and attention to the subject. They have not been attacked, nor do I believe they are at all attackable from the side of theory.

But from the side of experience an attack has come, and, strange to say, it has been directed, not at the few practical suggestions, which might be expected to be vulnerable on that side, but at the theoretical and purely scientific portions.

At the Bath meeting of the British Association the then President of Section G (Mr. Preece), speaking in the light of a most gigantic experience—a personal acquaintance with over half-a-million conductors—led a most good-humoured attack against the doctrine of my lectures, and, exercising his well-known rhetorical and oratorical powers, succeeded probably in impressing the general bulk of the audience with the belief that he had, on the whole, the best of the battle; though, at the same time, I expect they were in a state of utter bewilderment as to what the conflict had been all about, and where the difference "'twixt tweedledum and tweedledee" precisely lay. The battle was, however, admittedly a drawn one, and at its close Mr. Preece magnanimously offered me another field, with an audience of an altogether different calibre to the general public of Bath, by getting your secretary to invite me to read a Paper before this Institution.

Thus much by way of historical note and introduction. Now for the scientific portion of the Paper.

I begin by running over some of the conclusions at which I arrived, and proceed to re-establish and demonstrate their correctness either by theory or by fresh experiment, whichever may seem the more simple and satisfactory under the special circumstances.

Two Main Cases of Lightning Flash.

1. All discharge is virtually that of a Leyden jar. There are always two conductors separated by dielectric, and the discharge is a breaking down of the dielectric at its thinnest or weakest place.

In a thunderstorm the charged conductors are obvious, being either two clouds, or else a cloud and earth, and the dielectric is the air between.

2. It must sometimes happen, when one cloud discharges into another, that the potential of this other is suddenly raised high enough to cause it to discharge into the earth, even though no strain previously existed in the air between it and earth. The same thing may happen in various other ways when two clouds spark into each other, as indicated by the diagram (Fig. 1).

3. There are, therefore, two main cases—(*a*) When the strain in the dielectric near the earth has been of gradual growth, in which case the path of discharge will be prepared inductively beforehand; (*b*) when the strain arises so suddenly that there is no time for any pre-arranged path. The first I call "steady strain," the second "impulsive rush." It is most important to recognise these two cases, and to understand the extremely different conditions attending the two. The first case only was ever contemplated by the older electricians; in fact, so far as I know, it was my experiments last year which first called attention to the other case.

Conditions of Protection and of being Struck, under the Circumstances of each Case.

4. I will now illustrate experimentally the conditions under which discharge occurs in each of these two main cases, and I will take first the case of steady strain, or case *a*. This insulated sheet of tin plate is supported horizontally a foot or two above another plate lying on the table, and it is electrified by a Wimshurst machine. It represents a charged cloud hovering over the land, the lower plate representing the earth. Between the two I can

* Paper read before the Institution of Electrical Engineers on Thursday, April 25, 1889.

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erect buildings, and lightning conductors terminated in various ways. The typical terminals which I will here use to illustrate the conditions are four, viz., a large knob, or, as I shall call it, a "dome;" a small knob, which I shall call "knob;" a sharp point, and a gas flame to represent a chimney or other furnace current of rarefied air. Putting the knob and the dome between the plates, we find the knob struck by preference, even though the dome stands at a much higher elevation. Introducing the point, we find it protects both, by a silent discharge, until it is lowered very considerably; and that then several points may protect when one does not. Replacing the point by the flame, we find that it protects too, but not so efficiently as the point, and that it gets curiously beaten down and darkened in the act of protection. The point is not struck by a noisy flash until it is raised pretty close to the upper plate, when it is struck; but a bunch of points is even then not **easily struck, sometimes continuing to discharge silently right up almost into the cloud.**

5. Try the effect of a bad earth or other very high **resistance** interposed in the path of the conductor, say a capillary **water tube,** or a bit of wet rag, or a wet string.

The violence of the spark is lessened, and the sound **is now** gentle, but that which was struck before is still struck; **resistance,** so long as it be something short of infinite, makes no **difference to** the ease with which a given object is struck under **the circumstances** of this case 1. Insert the wet rag in path terminated by point, and it still protects, practically as well as before. **Insert it** in path terminated by knob, and it gets struck at the same **elevation** as before.

The fact is that the path of the disruptive discharge is all **negotiated** and pre-arranged in the air above, especially on the **surface** of any small conductor reared into this space, and the **resistance** which the flash may ultimately have to meet with in its passage to **earth is a thing of subsequent consideration.**

6. **So much for the conditions attending case *a*, the steady strain,**

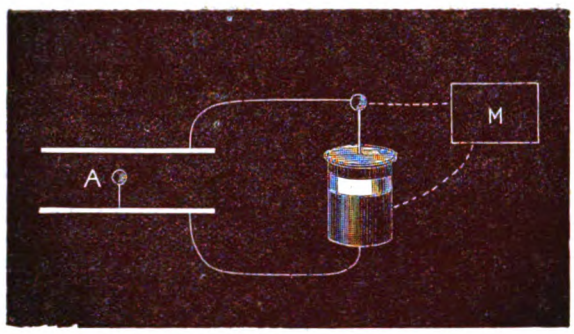

FIG. 1.—Case *a*.

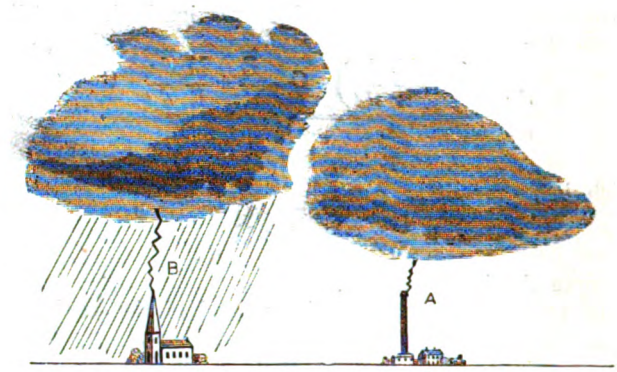

FIG. 2.—Case *a*.

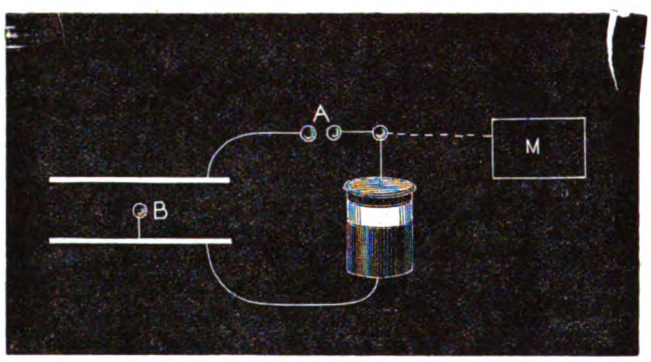

FIG. 1.—Case *b* (1).

FIG. 2.—Case *b* (1).

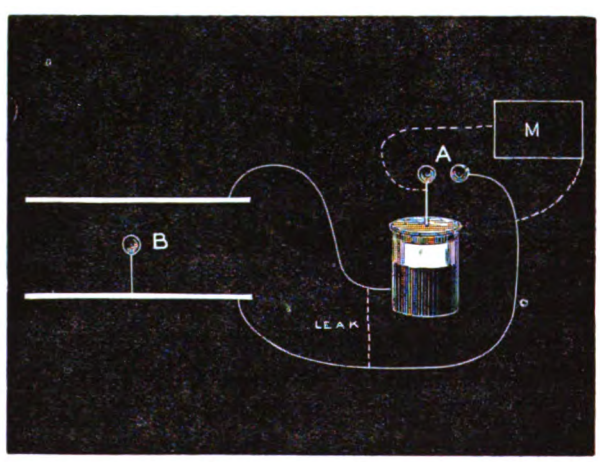

FIG. 1.—Case *b* (2).

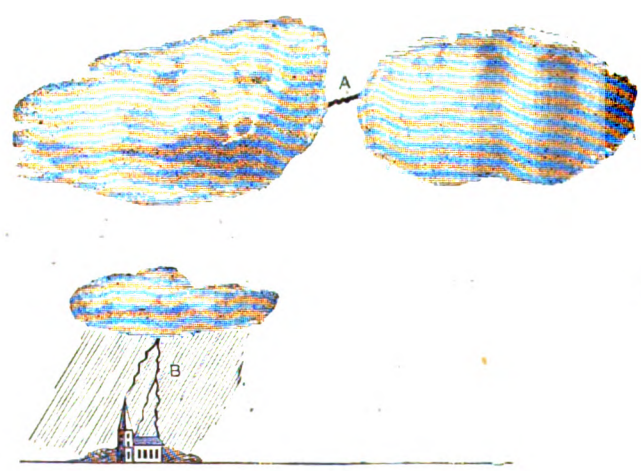

FIG. 2.—Case *b* (2).

Figs. 1 and 2 represent the same conditions as they may occur in nature and as they can be arranged artificially. Case *a* in each figure is the steady-strain case. The others are varieties of the impulsive rush, where a spark at A precipitates a spark at B, the place where B occurs having been subjected to no preliminary strain. Clouds correspond to coatings of jars; spaces between them correspond to glass or other insulating space. The position of the charging machine M is indicated in Fig. 1 for convenience.

The leak or imperfect conductor in the second case *b* of Fig. 1 is needful in order that the jar may charge. It takes no part in the discharge. Its place is taken in Fig. 2 by the rain-shower. In case *b* the rain-shower or leak are permissible but unnecessary.

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Now attend to case *b*, the impulsive rush. We shall find everything very different.

Alter the connection so that a charged Leyden jar must, when it discharges, discharge direct into the upper insulated tin plate, and thence overflow to the ground if it is able to raise the potential high enough. If the plate is too far above ground for a flash to occur, the Leyden jar does not completely discharge ; it only produces a number of fizzes and spits, and the greater part of its charge remains in it. But when the upper plate is within sparking distance of the ground (and the sparking distance under these circumstances is surprisingly great by reason of the impetus with which the electricity rushes into the top plate), then the jar discharges completely, and we have a violent crack both between the knobs of its discharger and in the air gap between the two plates which is in the path of the discharge, the arrangement being really two condensers in series but only one charged.

The only object of the Leyden jar in case *a* is to give more body to the flash. In case *b* the Leyden jar, or it equivalent capacity, is essential.

7. Putting the dome and the knob between the plates arranged as in case *b*, we find that one gets struck as easily as the other ; the knob has now no advantage : whichever is the higher that gets struck, without reference to other considerations. Introducing the point also, we find precisely the same is true for it ; its protective virtue, so much insisted on by the older electricians (among whom I suppose I am right in reckoning my chief antagonist), is entirely non-existent. It gets struck no more easily, and no less easily, than the dome, and it gets struck by a flash of precisely the same noisy character as the others get struck with. A bunch of points acts in exactly the same way. A comb of 24 needle points protects nothing, and gets struck just the same as anything else.

8. Now introduce the flame, and one notices a marked difference. In case *a* it protected less well than the point, but it was not struck noisily any more than the point was. In the present case it gets struck with violence, and it gets struck much more easily than anything else. Adjust dome and knob and point at about the same level, and they get struck, one or other, at random. Adjust the flame a great deal lower, and it protects them all, not by silent discharge, but by getting struck itself instead.

"Protection," however, is in this case not the word to use. The flame better represents a chimney requiring protection, while the point corresponds to the pointed terminal of a lightning conductor raised a good deal higher with the intention of protecting it. Protect it it does not, however ; the flash strikes down the column of hot air and through the flame, while it avoids the more lofty pointed terminal altogether.

Bring a point or a knob, or anything, *into* the column of hot air above the flame ; *then* it gets struck easily enough, and protects the flame, but not if it is on one side of the hot-air column. The experiment has an obvious moral in relation to the protection of chimneys ; it suggest that the Continental plan of a bar or arch across the mouth of the chimney may, after all, be justified.

9. Try the effect of resistance in the path of the discharger *now*, and we find it is altogether different to what it was in case *a*.

In case *b* things get struck according to their height, independent of the shape of their terminals, but not independent of their resistances.

Interpose a wet rag in the path of any one, and that one fails to be struck ; it is not struck, and it fails to protect the others from being struck, even though it be reared up till it touches the top plate.

The top plate need not therefore be insulated at all carefully for this case *b* experiment.

Imitation of Lightning.

10. Now let us modify case *b* by making the top plate a sieve full of water, so as to get the flashes in a shower of rain. One cannot well try case 1 in a rain shower : the plate would be discharged too rapidly and continuously by the water-drops for its potential to fully rise. But in case 2 the top plate is not necessarily charged at all until the rush comes, and so the rain shower does no harm.

Flashes in the rain can be got of surprising length and shape, for they make use of the water-drops as stepping-stones. By adding salt to the water they become longer still, but there is no need thus to improve its conductivity for what I want to show.

Notice how the flash contorts itself, taking sometimes extraordinary paths as it jumps from drop to drop, but yet exhibiting its instantaneous character by showing the drops as stationary in its illumination.

11. Remove the things standing on earth-plate just beyond fair striking distance, and what do we see ? Appearances precisely like those which are observed in many lightning photographs.

A crowd of violent discharges fill the rainy air—forks, and branch and multiple flashes, not very bright or very noisy, but extraordinarily numerous, and striking on innumerable places at once. A riot is set up in this air at every attempt of the jar to discharge, exactly as happens in one of the most striking of the photographs belonging to the Royal Meteorological Society.

Masts and spars and deck and ocean may be simultaneously struck by these interesting flashes, and though they do not here appear very violent, yet I expect that on the larger scale of Nature they are not very safe, and may easily have a heating effect sufficient to ignite bodies. These experimental ones are able to ignite gas in the midst of the rain.

12. While we have this arrangement at work we may as well try an interesting little experiment on what happens when lightning reaches water. The rain water has here been collected in a zinc tray some three inches deep, and by bringing a knob from the top plate, some six inches or so above the water, a flash strikes it. It prefers to strike anything metallic if it can, but if there is nothing else within reach it will strike the water. On reaching the water the flash forks out and ramifies in all directions in a crow-foot pattern, giving the same sort of appearance, only coarser, as that obtained by Mr. J. Brown by taking sparks on to a photographic dry plate and then developing.

Bring the knob nearer and nearer, the same thing happens, until the water is touched by the knob, and even after it is submerged. But as soon as the metallic conductor is submerged the ramifications get less and less vigorous, and when a sufficient surface is immersed they cease. I have never seen these ramifications spread of themselves *below* the surface of the water. They appear to me to keep entirely to the surface. But I have not yet finished investigating these appearances.

13. Immersing a half-full beaker in the water, sparks can be got to the water inside it, though they prefer to curl round and go outside. The noise the sparks make when they go inside is a curious one, and sounds as if the glass cracked each time, but it does not. If the glass is moist, a brush cascade round its edge can be seen in the dark. If it be dry, the water inside gets charged, and fizzes audibly back to the knob for a second or so after the spark has ceased, a dimple being visible in the water below the knob.

14. Live things in the struck water—worms, flies, fish, &c.—will most certainly get struck ; but so they do under far less violent disturbances than what they would here be subject to. There is nothing surprising in the fish of a pond or lake being killed by a flash of lightning ; and it has often happened.

When H.M.S. "Conway" was struck many years ago, and protected by its lightning conductors, it is related that the sea-water was seen to be luminous on all sides of the ship. This is exactly the effect I now imitate.

15. There is one more experiment on discharge in water which I have just tried, and which it is interesting to show.* I take a painted rod, and, protecting it by a glass tube, immerse its point under water in a beaker containing a plate connected to the other coat of the jar, and pass a spark. With the point negative there is a bright glow region round it every time, but the discharge is quiet. With the point positive, the flash is of a dazzling white, and is accompanied by a great deal of noise and violence, threatening to smash the Leyden jar, and throwing down the copper plate towards the bottom of the beaker with fury.

Oscillatory Character of Lightning.

16. Before leaving the outdoor department of our subject I must say a few words on one branch of it concerning which there is evidently considerable uncertainty and haziness abroad—I mean the oscillatory character of a lightning flash.

That a Leyden jar discharge is usually oscillatory must now be regarded as so extravagantly proved that any doubts that may have existed on the subject must surely by this time be cleared away, at least for the case where the discharge has to utilise a wire circuit. But perhaps it is still doubted for the case when a jar overflows its edge, or, still more, when it merely sparks through its own dielectric straight between the coatings.

Now, as I have insisted all along, a lightning flash is a spark through the dielectric of a jar whose two coatings are either two clouds, or else cloud and earth. Hence, if any importance is attached to the fact (as I believe it) that lightning flashes are oscillatory it is necessary to prove it for a Leyden jar sparking direct between its coatings, especially when the coatings are not very close together.

17. The reason I do attach importance to the oscillatory character of a discharge is because I have worked out the quantitative behaviour of conductors on that aspect of the matter ; and though, as Prof. Fitzgerald said at Bath, everything would hold just as well for a single oscillation—viz., one violent rise and decay of current (which without any doubt *must* accompany a lightning stroke or any other quick discharge whatever)—if rapid enough, yet the rapidity of such a charge as this does not seem to me prob-

* This experiment was not shown at the meeting, because in trying over in the afternoon the protecting glass tube was electrically broken.

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ably at all sufficient to account for some of the effects. The rapidity of variation of current in that case would be directly connected with the total duration of the flash ; and though we have evidence that it is very momentary, yet we have no evidence that it is so instantaneous (say a millionth of a second) as the semi-period of one of the oscillations may be, a dozen or more of which may accompany an entire flash. However, I admit, of course, that all I want is a tremendously rapid variation of current, and if I can be given this by one oscillation, the rest are unnecessary, and may be dispensed with.

18. When I speak of the oscillatory character of a flash, let it be understood once for all that I do not mean in the least such a thing as can be analysed by waggling the head. Flashes analysable by waggling the head must be multiple ones, and the interval of time between their constituents (which may be, say, the fiftieth of a second or thereabouts) is a long period compared with that of an oscillation such as I mean, bearing the same sort of ratio to it as a quarter of a century bears to an hour.

19. A direct experimental proof that lightning is oscillatory will be obtained when photographs of it are taken on a sensitive plate revolving 1,000 times a second. Something short of that speed would cause the image of the flash to blur, but that speed might be sufficient to analyse out the oscillations, when examined carefully with a magnifier, the focussing being good.

Till then the easiest proof that it is oscillatory is a theoretical one, and it can be put in a few words.

20. Consider an air condenser with two coatings, each of area A, separated by the distance h, and let it burst its dielectric. It is well known that the discharge is oscillatory when the whole resistance met with by the discharge is anything less than a critical value.

$$R_0 = 2\sqrt{\left(\frac{L}{S}\right)}.$$

Now, attending only to the straight part of the discharge, and ignoring the current rushing up in the plates to the spark path, the self-induction of a straight conductor of length h and sectional radius a is very approximately

$$L = 2\mu h \log \frac{4h}{a}.$$

The capacity of the discharged condenser is

$$S = \frac{K A}{4\pi h}.$$

Hence the critical resistance which must not be exceeded is given by

$$R_0^2 = \frac{32\pi\mu h^2}{K A} \log \frac{4h}{a};$$

or

$$R_0 = 10\mu h \text{ "r"} \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)}$$

$$= 300 \text{ ohms} \times \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)} \times h.$$

The important thing to notice in this value of $\sqrt{\frac{L}{S}}$ is that it is approximately proportional to the first power of h, the distance between the plates of the condenser.

21. Next consider the resistance of the discharge path. It too will be proportional to the length h, and it may be written

$$R_1 h,$$

where R_1 is the resistance per unit length of the discharge path.

The condition for oscillation, then, is that this $R_1 h$ shall be less than R_0 : or *the resistance of unit length of the spark must be less than*

$$300 \text{ ohms} \times \sqrt{\left(\frac{1}{A} \log \frac{4h}{a}\right)}.$$

22. The term under the square root will take different values according to circumstances, and it may be greater or less than 1 per metre. Ordinarily, however, it will be greater than 1 per metre, unless the area of charged surface is considerable. The important thing is the way in which h, the distance between the plates, enters into the expression. It does not come in very prominently at all, but so far as it does influence the result it permits the discharge to be oscillatory more easily when the plates are a good distance apart than when they are close together.

23. Take a couple of typical examples. First, a Leyden jar bursting its glass. A fine needle may be just put through the hole usually made in these cases, so we can take the sectional radius a as something like a tenth of a millimetre. The thickness of the glass may be 2 millimetres, hence $4h/a = 80$ or thereabouts ; and the natural logarithm of this is about 4. Suppose the area of coated surface is half a metre square, then the critical resistance which a metre of the spark must not exceed is 1,200 ohms, and so the 2 millimetres of it must not exceed 2·4 ohms.

It is difficult to say whether this is or is not a large resistance for such a short spark, and hence it is difficult to be sure that such a spark is anything more than a mere one-directional discharge. To go into it more fully the currents in the metal coatings would have to be considered. Next take as example a cloud area at an elevation of one kilometre ; and because a lightning discharge usually makes perforations of fair diameter, we may suppose a to be about a millimetre. (A widely erroneous estimate in this quantity makes but little difference in the result.) In such a case $4h/a = 4 \times 10^6$, and the logarithm of it is between 15 and 16. Hence the charged area may be 15 or 16 square metres without bringing down the square root term below 1 per metre ; so the resistance of the whole flash may in that case be anything below 300,000 ohms without checking the oscillations. The discharged area may indeed be as much as 1,500 square metres without bringing the critical resistance which the flash must not exceed below 30,000 ohms, or 30 ohms per metre. (Understand that "resistance" here does not mean impedance. It means true dissipation of energy resistance (sec. 25), and the current squared is so enormous (sec. 29) that the resistance-coefficient may be quite small).

In another place (*Phil. Mag.*, August, 1888) I have shown reason for believing that the area of cloud discharged at any one flash is usually very moderate ; and hence on the whole I consider it proved, so far as elementary theory can do it, that the lightning flash usually takes place under conditions favourable to oscillation.

24. And these oscillations are extremely rapid. The rapidity depends on the inverse geometric mean of L and S, and this is practically almost independent of h. Referring back to their values we see that

$$LS = \frac{\mu K A}{2\pi} \log \frac{4h}{a};$$

and so the number of complete alternations per second is

$$\text{"}v\text{"} \sqrt{\left(2\pi A \log \frac{4h}{a}\right)},$$

which, in the second example of Section 23, with A as 100 square metres, becomes

3 millions per second.

If the discharged area were as great as 10,000 square metres the rate of alternation would still be a third of a million per second.

(To be continued.)

SECONDARY BATTERIES.*

BY WILLIAM HENRY PREECE, F.R.S.

Secondary batteries are often called accumulators and storage batteries, and the general impression is that they accumulate or store that which is called "electricity." What is accumulated or stored is, however, energy in its chemical form. A *secondary* battery is really a battery pure and simple, but it differs from a *primary* battery in this, that the chemical character of the conductors or plates and the electrolyte in which they are immersed has been excited by an electric current which has passed through them continuously for some time, while in a primary battery the chemical affinities exist in the materials of which the cell is composed. In the language of the distinguished American, Judge Coxe, "A secondary battery is one which gives no electricity of itself, but is active only when rendered so by a current from an independent source."

Secondary batteries have become an essential feature of every properly equipped isolated electric light installation, not only for the regulation of electric currents and the maintenance of uniform electromotive force, but to give a store of energy to draw upon at night and when any accident or failure occurs. They are also employed for the distribution of electrical energy from central stations. They are used for ship and for train lighting, and they seem destined to solve the important question of economical traction on our tramways. They are much used in telegraphy. They have passed through a very severe ordeal of seven years' practical development in the face of determined opposition and in spite of the prejudice resulting from disastrous commercial speculations and from the non-fulfilment of over-sanguine hopes and hasty utilitarian anticipations.

The father of lead secondary batteries, in a scientific sense, is the eminent French electrician, Gaston Planté, but the final stroke that made the apparatus a real practical instrument was the discovery of Faure, who showed that the application of oxides of lead,

* Paper read before the Society of Arts, May 1, 1889. This subject has been before the society on two occasions. In 1881 (vol. XXX., p. 30) Prof. Silvanus Thompson read a Paper on the "Storage of Electricity," and in 1883 (vol. XXXI., pp. 1025, 1038), Prof. Oliver Lodge, F.R.S., gave two lectures on "Secondary Batteries."

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in the form of a paste or cement on the surface of the lead supports, so hastened the process of formation of the plates that the battery was made a commercial and valuable instrument. Sellon, Volkmar, Swan, Julien, Parker, King, Drake and Gorham have added so much to the mechanical details, and have done so much to remedy defects and remove faults of construction, that all we want now is to crystallise into practical language the teachings of experience.

My house has been lighted by these batteries since March, 1884, now five years ago. I commenced with seventeen Planté cells, manufactured by Elwell, Parker and Co., of Wolverhampton, charged by currents from a dynamo driven by a 2 horse-power gas-engine, but after two years of experimenting I selected twenty-six cells of the 15L E.P.S. type, with which form of cells I am now working. Their value can be illustrated by the following fact :—On March 30 my gas-engine broke down. I qulte forgot to give notice to the makers to send down men to repair it until six days had elapsed. It took five more days to repair the engine, so that for eleven days I had not been able to re-charge the cells ; but during all these days the light never failed, and we were not in any way inconvenienced. The useful capacity of my cells is 330 ampere-hours, and my nightly consumption is now about 30 ampere-hours. This was a very good test of the efficiency of the cells, for I obtained from them nearly all the energy they could usefully give. Only two cells were really exhausted during this time, but as I had two spare cells to replace them, their exhaustion did not cause me any inconvenience. The E.M.F. fell to 1·8 per cell, and the light in consequence was not so brilliant as usual. A good practical test of the efficiency of a battery like this is better than any isolated tests on single cells.

The illumination of this hall (Society of Arts) is regulated by 58 E.P.S. cells, of 13L type, an obsolete form, which are used, when the hall is not open, to light the secretary's and the public offices. They have been at work here since January, 1885, and have given no trouble and very great satisfaction.

Types of Cell.

There are several kinds and types of cells in use at the present day, but the principal ones supplied in England are by the Electrical Power Storage Company and by Elwell-Parker Company (Limited). The E.P.S. cells are of several patterns :—

"L"—Stationary cells used for electric lighting, motive power, and general purposes.

"T"—Portable cells used for tram-car and launch propulsion.

"C"—Portable cells for railway-carriage lighting.

Of the "L" pattern the following are the sizes issued :—

No. of plates.	Weight.	Maximum rate of discharge (amperes).	No. of 10 candle-power lamps. (26 cells).	Capacity (ampere-hours).
	lbs.			
7 L	68	13	21	130
11 L	101	22	36	220
15 L	128	30	50	330
23 L	211	47	76	500
31 L	265	64	100	660

There is always one more negative plate than positive.

E.P.S. Type, 1888.

The plates of each cell are divided into the positive and the negative, in each case a pure lead grid being cast for retaining the paste-oxide $8\frac{1}{2} \times 9\frac{1}{8} \times \frac{3}{16}$ thick, and weighing 5lb. The perforations or openings of the positive plate are filled with minium, while those of the negative plates are filled with litharge. The plates so prepared are then subjected to powerful currents for several hours, when the litharge (PbO) is reduced to spongy lead (Pb), and the minium and red-lead (Pb_3O_4) become lead peroxide (PbO_2). There is thus economy in reducing the lower oxide and in peroxidising the higher one. Many attempts have been made to manufacture the grids of inoxidisable alloys, such as an alloy of antimony and lead, to which mercury is sometimes added, but so far nothing seems to be superior to the pure lead itself. The principal defect has been that of buckling or deforming, and this is supposed to be due to irregular oxidisation, but no clear explanation has yet been given of the remarkable way in which lead plates curl and curve under the influence of electrolysis. Plates do not buckle when they are properly treated. It is the rough handling of cells—calling upon them to do more than they were designed for, neglecting to maintain the level of the liquid and its density—that principally lead to deformation, disintegration, and also short circuiting from the paste falling out in plugs and resting across the plates. The plates are now fixed $\frac{3}{8}$ths of an inch apart, a sufficient distance to allow any pellet that may fall out to drop harmlessly to the bottom of the cell. This distance can be increased with advantage.

The pellets of paste are now made considerably smaller than was the case at first, and this has been done to hasten the period of formation, and to render the whole of the pellet active, which was not always the case with the larger pellet, for their centres were often found unformed, and therefore idle.

The negative plates of each cell rest on toes or blocks, and are maintained $1\frac{1}{2}$ inches clear of the bottom of the cell, and they suspend the positive plates by lead bars running along each side of the negative section, on which ebonite supports carry the positives. All the plates of each kind of each cell are welded or burnt on to a broad lead strip, to which either a terminal is attached, or which is burnt on to the strip of the next cell.

The "L" cells, for fixed permanent installations, are of glass, but for ship, tram, and train purposes they are generally fixed in wooden boxes, rendered water-tight by lead, marine glue, or ebonite linings. Glass is much preferable to wood, or to any opaque substance, for it is very useful to see how the plates and their packing are behaving. Elwell-Parker introduced a cell made of an inoxidisable alloy, but it has not been received with favour.

Glass has this advantage, that it is an excellent insulator, though owing to its hygroscopic tendency it has been found necessary in some cases to mount the cells on oil cups—a plan that is always necessary with wood and metal boxes.

The electrical leakage from glass cells when the acid spray is checked is very small indeed. They retain their charge unimpaired for months. It is, however, a good plan to paint the glass over with paraffin or vaseline occasionally. It checks leakage and prevents the acid from creeping.

Elwell-Parker Cell.

The form of cell supplied by Elwell-Parker differs in several details from the E.P.S. pattern, though it is of the same type. The plates are held together by side frames of wood or vulcanite at the edges so as to knit them together very firmly and prevent buckling. The whole frame of the largest size can be lifted in and out by a crane with ease. The negative plates are made in a way which prevents blistering, a defect in the E.P.S. plates, and the grids are burred in a way which prevents the pellets from dropping out. This process, due to Messrs. Drake and Gorham, is an important improvement.

Capacity.

The capacity of a cell is the amount of energy it will accumulate and usefully restore. It is measured roughly either in ampere-hours or in watt-hours. The latter is the more accurate if the fall of E.M.F. is carefully noted, but if the E.M.F. is maintained fairly constant by not running the cells too low, the former is equally practical and more common, The average type of cell, such as the stationary E.P.S. pattern, gives a useful capacity of 4 ampere-hours per lb. of plates complete. I have had a cell (Fitzgerald's lithanode) which gave a return as high as 5·7 ampere-hours per lb., while the Planté type rarely exceed 2 ampere-hours per lb. The portable form used for traction purposes gives 5 ampere-hours per lb., but this is only because the plates are much lighter.

Efficiency.

The efficiency of a cell is the ratio between the energy taken out of it to the energy put into it, and the useful efficiency is usually taken from the number of ampere-hours discharged when the E.M.F. falls 10 per cent. in magnitude, This figure is a very variable quantity, for it depends very much on the current density ; that is, upon the number of amperes per unit of surface—one square centimetre—of plate. The following experiment on a small cell illustrates this point :—

Current density.	Ampere-hours.
·013	44·6
·048	36·5
·09	30·2

The ordinary current density, which should not be exceeded in practice, is ·01. This means that the maximum output should not exceed 4 amperes per positive plate.

A cell will discharge many more ampere-hours than are given by this useful efficiency, and if the discharge be taken with a very small density the efficiency may reach a very high figure. Thus 95 and 98 per cent. have been obtained from small cells slowly discharged. The efficiency of a cell therefore varies with its rate of discharge. If the efficiency with an output of 5 amperes be 90 per cent., it will be only 50 per cent. with a discharge of 40 amperes. Batteries drop in E.M.F. if the rate of discharge is high or the current density great. They should, therefore, be discharged at a slow rate. The most general maximum rate is found to be that which discharges a cell in ten hours. Thus the discharge of 15 L cells should not exceed 30 amperes, nor that of 31 L cells 60 amperes.

It is sometimes thought that because the E.M.F. in charging is 25 per cent. greater than in discharging, there must be a loss of energy to that amount, but the fact is this loss of E.M.F. is compensated for by gain of current, owing to the reduction in the internal resistance of the cell. The internal resistance of a cell, which is normally about ·0003Ω per positive plate, diminishes with the strength

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of the current of discharge, and therefore it is possible to get nearly all of the energy out of a cell that has been put into it. The efficiency of a secondary battery increases with the lightness of the load put upon it, and in this respect it possesses a great advantage over that other transformer of electric energy, namely, the secondary generator of Gaulard.

It has been the practice to place the plates in a cell very much too close to each other. This not only favours short circuiting, but it prevents the free circulation of the electrolyte. Recent experiments have also shown that efficiency has also been improved by increasing the distance between the plates.

The Electrolyte.

The character and the quality of the electrolyte used in secondary cells has scarcely received the attention it deserves. Hitherto scarcely anything but a solution of sulphuric acid has been employed. Experience seems to show that the best solution to use before charging is one which has a density of 1·150. Such a solution in a 15 L cell, when fully charged, will acquire a density of from 1·210 to 1·220, and it is customary to maintain the density of the cells somewhat between 1·170 and the higher figure. One of the great troubles with secondary cells that are imperfectly and improperly treated is the formation of the white sulphate of lead that is frequently seen upon both plates. In fact, it is the root of nearly all the ills that these cells are heir to. There are many ways of getting rid of this sulphating. The plan used by Mr. Sayers, the engineer in charge of the St. Pancras Hotel installation, is described by him as follows :—

"Our battery of 120 15 L cells was rather badly covered with sulphate of lead. At first I simply charged them with the ordinary maximum charging current, 30 amperes, when each cell on becoming full would give about 2·5 volts. The sulphate, however, did not apparently move. I then tried charging with 40 or 45 amperes for a few weeks, and the change in the look of the plates—of the peroxide plate chiefly—was considerable. They began to exhibit patches of the well-known plum-coloured peroxide, and nearly all had the appearance of a peroxide plate covered with a lace-work of sulphate of lead. This lace-work, also, soon nearly entirely disappeared, and the majority of the plates are now looking very well. The E.M.F. of each cell, with 40 amperes charging current, is about 2·7 volts when the cell is milky. I have thought that this result was due either to the fact—if it is a fact—that sulphate of lead requires more than 2·5 volts to decompose it thoroughly—say 2·6 volts—or that the large quantities of nascent hydrogen attack the sulphate and combine, making sulphuric acid and lead."

It occurred, however, in 1886, to Mr. Barber-Starkey, of Aldenham-park, near Bridgnorth, to see if carbonate of soda in the presence of lead had any beneficial effect upon plates liable to sulphating. The result was very satisfactory; all traces of sulphating disappeared. He treated his own cells in this way, and the effect was so decidedly advantageous to all appearances that I determined, after careful inspection and inquiry, to make an exhaustive experiment that should determinethe question, and at the same time settle the best proportion to use. Six new 15 L cells of the Elwell-Parker make were taken, and they were charged with solutions in the following manner :—

No.	Sulphuric acid.	Sulphate of sodium.	Water.
1.	5 pints.	5 pints.	15 pints.
2.	5 ,,	4 ,,	16 ,,
3.	5 ,,	3 ,,	17 ,,
4.	5 ,,	2 ,,	18 ,,
5.	5 ,,	1 ,,	19 ,,
6.	5 ,,	—	20 ,,

The sulphate of sodium solution was prepared by first making a saturated solution of carbonate of soda (ordinary washing soda), and then adding thereto sulphuric acid until effervescence ceased. The cells so prepared have been charged and discharged, and watched with great care from May 1st, 1888, until the present day. We, therefore, have exactly twelve months' experience of their behaviour, and there can be no doubt as to the beneficial result. The solution marked No. 5 is that which has given the best results, and after about six months' experience of its behaviour two complete sets of 52 No. 23 L cells were charged, the one with the ordinary sulphuric acid solution of 1·175 density and the other with sulphate of sodium solution of 1·225 density. Six months' experience of these two sets has confirmed the result that immense benefit is to be derived from the sulphate of sodium solution. There has been no evidence of buckling, there has been little or no scaling. The bottom of the cells are nearly as clean as when they were first discharged, while the bottom of those charged with the sulphuric acid solutions have the usual accumulation of oxides of lead. Two cells were also and at the same time charged, the one with the sulphuric acid and the other with the sodium solution, and very careful tests of these two cells show that the addition of soda does not impair either the E.M.F. or the internal resistance, nor does it diminish the output of the cells. I have, therefore, come to the conclusion that the addition of soda has a distinct beneficial result, and it is my intention to use it invariably in future. The cells so provided remain in splendid condition. They can be left for months without developing any trace of sulphating or even of loss of charge. Carbonate of soda thrown into a badly-sulphated cell unquestionably leads to the rapid removal of the sulphate of lead, and this is supposed to be due to the fact that a carbonate of lead is formed which is easily reduced and always produces beautiful deep puce-coloured peroxide of lead.

Mr. R. Davids writes, January 18, 1889, to me from Campinas, Brazil :—"As might have been expected, the cells (which had been delayed in transit) were very badly sulphated, but after 24 hours' charging I gave them a dose of soda, which proved a *santo remedio*."

The electrolyte that I recommend for adoption is this :—To a quart of saturated carbonate of soda solution add slowly, during continuous agitation, 12 fluid ounces of strong sulphuric acid ; fill the cell with water 19 parts, strong sulphuric acid 5 parts, soda solution 1 part ; total, 25 parts. The specific gravity of this electrolyte should be 1·210.

It is a mistake to use cells of too small a capacity for stationary purposes. This is usually done for economical reasons, owing to the capital expenditure involved in purchasing cells. Twenty-six 15 L cells cost £78, and the same number of 23 L cells cost £117, but I believe it to be true economy to expend the additional £39. Greater efficiency is obtained out of the larger cells now that soda has prevented injurious sulphating, for you are not limited to a minimum current as you are with the sulphuric acid solution. Small charging and discharging currents mean not only greater efficiency but greater durability of the plates. Secondary batteries used for telegraphy show no sign of disintegration. It is overtaxing cells that destroys the plates. Mr. Barber-Starkey's cells at Aldenham Park have now been in use for three years, and to all appearances they are quite as perfect now as when first set up.

Maintenance.

The chief secret of the successful working of a set of secondary cells is careful and regular attention to their behaviour, and the immediate remedy of any defect that may develop. They require daily testing and inspection. My battery is tested every morning for E.M.F. by means of a Cardew's voltmeter. If the total number of volts divided by the number of cells is not over 2 per cent., each cell is tested separately by a portable Walsall voltmeter, graduated to tenths of a volt, until the defective cell is found. This has very rarely happened—in fact, only once during during the past twelve months, when a plugging fell out, rested between the two plates, and short-circuited the cell.

Six cells are also tested every morning for density by a hydrometer, which is recorded in a book. The six cells are changed every month, so that each cell of the battery passes through this ordeal three times a year. The regular rise and fall of the specific gravity of a cell is the very best criterion one can have of its good working. I cannot do better than transcribe the record of one week's testing.

"Gothic Lodge" Engine Room.—28 E.P.S. Cells.

Date.	Current.	E.M.F.	Cells (Density).*				
			8	14	18	20	26
April 24	—	57·5	1210	1215	1190	1225	1225
,, 25	—	57·5	1210	1205	1185	1220	1220
,, 26	—	57·	1205	1195	1180	1215	1215
,, 27	Charging.						
7:30 a.m. ...	26½	60	1200	1190	1175	1210	1210
10:0 ,, ...	30	64	1205	1195	1180	1215	1215
12:0 ,, ...	31	67	1210	1200	1185	1220	1220
2:0 ,, ...	31	69	1210	1205	1190	1225	1225
4:0 ,, ...	31	70	1210	1210	1200	1225	1225
April 28	—	57·5	1210	1205	1195	1225	1225
,, 29	—	57·4	1205	1200	1190	1220	1220

* The density of the cells requires to be equalised periodically.

The normal density when the cells are charged should be 1·220. They fall 1 for every 5 ampere-hours taken out, and when they reach 1·150 they are exhausted. The density is thus a record of the energy that has been taken out, and of that which remains in.

Occasionally I test them for internal resistance (ρ), both when charging and discharging. In the latter case the discharge current into the house is regulated by lamps to give 10 amperes when the E.M.F. (E_1) at the terminals is read. The E.M.F., when the ends are free (E_2), is also read. Then—

$$\frac{E_2 - E_1}{10} = \rho$$

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I make the current 10 for the internal resistance varies with the current,* and by always using the same current I have an accurate comparison. The internal resistance of my 15 L cells is usually ·0012 ohm. per cell when discharging, and ·005 when being charged.

When a cell becomes defective by short circuiting or any other cause, the plates are taken out, their faces scraped and straightened, the solution cleared, and the cell thoroughly cleaned. The cell is always benefited by such a process, for the cleaned cell is always the first to come up to the charge by as much as 1½ hour.

The cells in this building have been very carefully tended during the four years they have been at work. Only three sets of positive plates have been renewed.

In charging cells, there are three distinct indications that the cell is fully charged :—

1. The E.M.F. suddenly rises up to 2·5 volts per cell.
2. The hydrometer indicates 1·220.
3. The electrolyte becomes milky by the fine bubbles of gas that float in the disturbed solution during their gradual ascent to the surface and escape into the air.

The rise of bubbles of gas to the surface and their bursting scattered a considerable amount of acid spray about in the battery room, which was injurious to metals and apparatus ; but Mr. F. Higgins, Memb.I.E.E., showed how to prevent this by covering the cell with a fine net or with calico. Glass plates are now much used instead of calico, but I have adopted Mr. Henry Edmunds' plan of pouring upon the surface of the solution melted paraffin, which solidifies and coats the surface with a uniform thin layer of what looks like ice.

It is necessary to be cautious in approaching cells with naked lights when they are being charged. There are several instances of explosion and injury to person in consequence.

The chief defect of the negative plate is that the plugging scales and falls off in thin flakes. This, in the recent types, falls harmlessly to the bottom, but it should not happen at all, and it is due either to imperfect material or to hasty formation. The negative plate should certainly last for ten years. The positive plates also disintegrate, and to a much greater extent. The disintegration of the lead peroxide seems to be a necessary consequence of the action of the cell. It varies with the rate of discharge. If the cells be worked heavily it occurs rapidly, but if the maximum rate of the output of about four amperes per plate be adhered to, the duration of the plate may be taken to be three years. The decay of the positive plate seems to occur almost entirely in the lower half of the plate, and this is probably due to the greater density of the solution favouring unequal distribution of current.

Central Stations.

The secondary battery lends itself admirably under certain circumstances to the economical distribution of electric currents from central stations. It is possible to lay down a long main circuit of small dimensions, conveying a direct current of high E.M.F. which at different points can charge a secondary battery of a small number of cells, so as to "transform" the dangerously high E.M.F. into one of a low and harmless character in the building to be illuminated ; in fact, this is now being done in Chelsea by two different companies. The one company, the Chelsea Electricity Supply Company, is acting under the statutory powers of a Provisional Order, and it distributes its currents to the houses from sub-stations, where the batteries are kept and maintain a continuous supply of electric energy. Each sub-station, of which there are three, supplies current for 2,000 30-watt 10 candle-power lamps. There are 265 31 L cells, divided in two sets of groups of 53. Each set is charged separately and alternately in series from the central generating station. While one set is being charged the other is supplying currents to the consumer. The main charging current of 60 amperes has an E.M.F. of 500 volts per distributing station, or 1,500 volts for the present circuit ; and the secondary discharging supply into the houses has a pressure of 100 volts. This system of distributing currents from batteries has many advantages. The currents being direct are available at once for motor purposes, as well as for lighting. The currents being so steady and uniform add to the durability and life of the lamps. The supply being continuous day and night, it is always available, just as is the light from gas. The distributed currents being of low E.M.F., absolute safety to person is secured in such a system. The engines at the central station, being always worked at full loads, can be worked under their most economical conditions, and as they cay be worked continuously throughout the twenty-four hours, a minimum capital expenditure in engine plant is necessary. It has already been pointed out that the efficiency of the battery is not much affected by variations of its own load, and that whether one lamp or 100 lamps be used it is of not much consequence to the cells ; in fact, the efficiency of the lighter load is the highest. On the other hand, it must be pointed out that there is a considerable capital outlay required in batteries. The depreciation of the cells is very considerable, and there is an appreciable loss of energy at each transforming point. The maximum efficiency of batteries in practice rarely reaches 70 per cent., while less than 15 per cent. for depreciation can scarcely be allowed with prudence. The batteries for 1,000 lamps cost £1,325, or 27s. per lamp. The reliability, constancy, and permanence of the light from batteries compensates for many another evil. The other company in Chelsea—the Cadogan Electric Supply Company—places the batteries in the houses, and charges 1,000 E.P.S. 31 L cells over a circuit of nine miles.

There is a central station in Detroit, in the U.S.A., also distributing by batteries, and giving great satisfaction.

The Kensington-court Central Station, established by Messrs. Crompton and Co., and that at Whitehall-court, also use secondary batteries, but the batteries are in the stations and not in the houses. They are used more for regulation and for reserve force purposes than for distribution.

There is also a large central station at Vienna, and one at Darmstadt of the same character.

An extremely ingenious mode of distribution has been proposed by Mr. Henry Edmunds. The battery is divided into four groups. Three groups are jointed in series, and supply energy to the house, while the fourth group is in the main being charged. These groups constantly and continuously change places every three minutes by means of an automatic switch. A third of the battery is, therefore, always being charged, and this means that only one-third engine-power is needed at the central station, and only one-third of the E.M.F. on the changing main. Mr. Edmunds' automatic distributor is an extremely ingenious apparatus, but it has not yet received the test of practical trial, though the sooner it does so the better.

Mr. Preece concluded his Paper with a few remarks upon the application of secondary batteries to electric traction, portable lamps and telegraphy.

* Preece, *Proc.* Roy. Soc., May 6, 1885.

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, May 3rd.

Institution of Mechanical Engineers.

2:30 p.m. Ordinary General Meeting. "Description of an Apparatus for Drying in Vacuum." By Emil Passburg, of Breslau.

Society of Arts.

8 p.m. Indian Section. "The Karun as a Trade Route." By Major-Gen. Sir R. Murdoch Smith, K.C.M.G.

Royal Institution.

9 p.m. Evening Discourse. "Aluminium." By Sir Henry Roscoe, F.R.S.

SATURDAY, May 4th.

Royal Institution.

3 p.m. Afternoon Lecture. "The Origin and Development of Opera in England (with Musical Illustrations)." By Joseph Bennett.

MONDAY, May 6th.

Royal Institution.

5 p.m. General Monthly Meeting.

Society of Engineers.

7:30 p.m. Ordinary Meeting at the Town Hall, Westminster. "Recent Developments in High Explosives." By Perry F. Nursey.

Society of Arts.

8 p.m. Cantor Lecture VI., I. "Heat Engines other than Steam." By H. Graham Harris, M.I.C.E.

TUESDAY, May 7th.

Royal Institution.

3 p.m. Afternoon Lecture. "The Italian Renaissance Painters: Their Education." By Jean Paul Richter, Ph.D.

Institution of Civil Engineers.

8 p.m. Ordinary Meeting. "The Treatment of Steel by Hydraulic Pressure, and the Plant Employed for the Purpose." By W. H. Greenwood, M.I.C.E. At this meeting the monthly ballot for members will be taken.

WEDNESDAY, May 8th.

City and Guilds of London Institute Old Students' Association.

7:45 p.m. Ordinary General Meeting at the Finsbury Technical College. "The Construction and Maintenance of Secondary Batteries." By J. Appleton, Member.

Society of Arts.

8 p.m. Ordinary Meeting. "Origin and Manufacture of Playing Cards." By George Clulow, F.R.G.S.

THURSDAY, May 9th.

Royal Institution.

3 p.m. Afternoon Lecture. "The Science of Animal Locomotion in its Relation to Design in Art (Illustrated by the Zoopraxiscope)." By Eadweard Muybridge.

Institution of Electrical Engineers.

8 p.m. Ordinary General Meeting. Discussion on Dr. Lodge's Paper on "Lightning, Lightning Conductors and Lightning Protectors."

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The Electrician.

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CONTENTS OF THE CURRENT NUMBER.

NOTES 725
The Use of the Integraph in Determining Some Problems in Electro-Dynamics. By L. B. Atkinson. Illustrated. Continued 730
The Institution of Electrical Engineers—
"On Lightning, Lightning Conductors, and Lightning Protectors." Illustrated... 731
"Underground Conduits and Electrical Conductors." Illustrated. Concluded..... 746
Secondary Batteries. By William Henry Preece, F.R.S.... 734
Meetings of Scientific Societies. 737
UNDERGROUND CONDUITS..... 738
The Board of Trade Inquiry on the London Electric Lighting Provisional Orders 739
American Notes 748
Notes from Vienna 749
CORRESPONDENCE—
Dr. Lodge's Experiments.—"Ignoramus" 749
Arc Lamps for Amateurs. Illustrated.—R. P. Bouquet. 750
Lahmeyer's System of Regulation.—R. H. Housman.... 750
The Injunction Against the Julien Company.—H. Dell 750
COMPANIES' MEETINGS, &c.—
The Indo-European Telegraph Company (Limited)..... 750
Great Northern Telegraph Company of Copenhagen (Limited) 751
The Brazilian Submarine Telegraph Company (Ltd.) 752
The West India and Panama Telegraph Company (Ltd.) 752
The West Coast of America Telegraph Company (Ltd.) 753
New Companies Registered ... 753
Companies' Share List..... 754

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SPECIAL NOTICE.

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UNDERGROUND CONDUITS.

So much has been written and said about the dangers of overhead wires that it is perhaps with a slight sense of relief that we now begin to hear something of the dangers of placing them underground. At all events this may very naturally be the feelings evoked in New York, where partisanship extends to almost every relation of life, and where the advocates of opposing systems of wiring are ticketed "overhead men" and "underground men" respectively. Both of these parties have lately been enjoying lively times, the underground men doing great execution with the axe and chopper, the overhead men with explosive gases. The battle is not yet over, and it is hard to say which will get the best of it; but already it is plain to be seen that neither party will be completely victorious. Neither overhead wires nor underground wires, as such, are in themselves dangerous or objectionable, the risk and offence being due solely to attending circumstances. In certain large cities of the United States, however, notably in New York, the

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attending circumstances are peculiarly inimical to both systems, owing on the one hand to overcrowded and chaotic erections overhead, and on the other to the gas-laden and steam-saturated condition of the soil underneath. Just at present we in this country are able to say that those conditions do not prevail with us. But we cannot be quite sure of being always or wholly exempt from them; and at any rate there is something to be learnt from the state of affairs which has recently been disclosed in New York, and which therefore it may be well to take note of.

For a long time past the "overhead men" have with a few exceptions deliberately ignored the edict which had bidden them take all their wires underground. The Board of Electrical Control had caused to be constructed several miles of conduit, consisting, as our readers may recollect, of iron piping embedded in concrete. But the companies have hitherto shown very little alacrity in availing themselves of its use. The experience of the Western Union Company, which was the first to attempt to obey the law, was not of a character to encourage the others, since in the "down town" district its wires were saturated with hot steam and the insulation ruined. Meanwhile gas explosions of a more or less serious character occurred from time to time in various portions of the conduit. The recent Presidential election, however, brought a fresh man—presumably from "underground"—to the head of the New York municipality. The new Mayor, prompted by the Board which, in the language of our New York correspondent, "lives and moves and draws its salary" on the strength of its regulations, at once took vigorous action to enforce them, a brigade of ruthless mercenaries issuing forth armed with pickaxes and choppers, the upshot of whose onslaught was that many miles of overhead wires—telegraphic, telephonic, and electric lighting—lay prone on the ground, if not underneath it. One result of this proceeding was that the streets were left in partial darkness, gas lighting taking the place of electric, to the great discomfort of the inhabitants. Another result appears to have been that the underground conduit manholes became more turbulent than ever. Perhaps this was to be expected in a city where making a policeman to "move on," or a telegraph messenger to mend his pace by explosions into mid-air, afford only material for cynical humour. But they have their serious side no doubt to the victims, and in England certainly these playful vagaries of underground conduits will not be treated as a joke.

That the Board of Electrical Control in New York has treated the incidents seriously arises probably from the necessity of defending the conduit system, which so far as the Board's inquiry has gone is proved to be faultless in every particular save one—namely, that it is ill-adapted to the condition of the soil in which it is laid. This to ordinary onlookers would seem fatal, but not so to the Board. The fault lies with the gas companies and the steam-heating supply companies, whose liberality is so unbounded that the subsoil in which their pipes are laid absorbs nearly as much gas and steam as are supplied to the customers overhead. So thoroughly is the soil on which some parts of New York are built saturated with vagrant gas that speculation is said to be on the move to utilise the earth as a natural reservoir for the purpose of lighting the thoroughfares. Certain it is that the manholes ever since their construction have become so many receptacles for infiltrated gas, which combining with the air contained in them has produced an explosive mixture ready to be discharged on the smallest provocation. The question here arises, Whence comes the provocation?—in other words, the ignition?

This question is not easily answered, but as it is one that probably will be often asked, some attempt at a solution of the enigma should be made. The manholes are water-tight, if not air-tight, and perhaps only an underground man would suggest that the gas can be exploded by malice or accident from without. Overhead men of course fix the blame within, attributing the ignition to an electric spark, or to atmospheric conditions which may possibly favour an explosion. Of these atmospheric phenomena we can only say that although highly conjectural they ought to be either refuted or substantiated. The electric spark is more intelligible, and Mr. VERITY, in his recent Paper at the Institute of Electrical Engineers, speaks of cases where "pinholes" have been made in electric cables by disruptive discharges between the conductor and the exterior covering of lead. The genesis of such discharges is not easy to account for, even on Mr. Acheson's "condenser" theory.

In regard, however, to the origin of the inflammable gas—which may not always be coal gas—our attention has been drawn to the account of an incident which occurred in 1879 when the Kampi Cable House, near Banjowangie, Java, was connected with the Eastern Extension Telegraph Company's Singapore cable, which landed about thirteen miles away. The wires were drawn through a two-inch gas piping, which had to be kept filled with water. The narrative goes on to say: "Not many weeks had elapsed when we became aware of the presence of enormous quantities of gas which issued with explosive force whenever one of the vents was opened. One day when Mr. RENTZSCH was standing by one of the vents from which this gas was issuing, he said, 'I wonder whether it will burn?' and suiting the action to the word, applied a lighted match to the vent. With a bang a flame shot up six feet high, singeing his hair and whiskers. The gas, I believe," says the writer, "is carburetted hydrogen, generated by the decomposition of the tape with which the wires were covered as a protection whilst drawing them into the pipe." It was found that the only way of preventing this accumulation of gas was to keep up a continual flow of water through the tube. We regret that our informant does not exactly describe the "tape" covering, but its character can easily be conjectured. The moral of the story, however, lies in the two facts—first, that there was no gas company within a thousand miles of Kampi, and secondly, that the point of danger there, as at New York, was the vent-hole. At Kampi, however, we have the man with a lighted match to explain the ignition, whereas at New York neither man nor match has yet been discovered.

THE BOARD OF TRADE INQUIRY ON THE LONDON ELECTRIC LIGHTING PROVISIONAL ORDERS.

This Inquiry has been continued at the Westminster Town Hall since our last report. The following gentlemen represented the various parties concerned:—

Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham appeared for the London Electric Supply Corporation; Mr. C. A. Cripps for the Metropolitan Electric Supply Company; Mr. Moulton, Q.C., and Mr. R. S. Wright for the Chelsea Electricity Supply Company; Mr. Muirhead for the St. James's and Pall Mall Electric Light Company; Mr. Roger W. Wallace for the Notting Hill Electric Light Company, for the Kensington and Knightsbridge Electric Lighting Company, and for the Westminster Electri Supply Corporation; Mr. Moulton, Q.C., and Dr. Hunter, M.P., for the Electrical Power Storage Company; Mr. G. Prior Goldney (the City Remembrancer) for the City of London; Mr. T. Percy Gunyon (engineer) and two members of the Council for the London County Council; Mr. C. A. Cripps and Mr. F. M. Jenkins for the Strand District Board of Works; Mr. Hopwood (solicitor) for the Holborn District Board of Works; Mr. E. Bayley (clerk) and Mr. G. W. Thompson (surveyor) for the St. Olave's District Board of Works; Mr. James Spencer for the Greenwich District Board of Works; Mr. J. H. Horton for the Paddington Vestry; Mr. Hitchins for the St. George's (Hanover-square) Vestry; Mr. Wilkins (clerk) and Mr. W. Jenkins (chairman of the Lighting Committee) for the St. James's (Westminster) Vestry; Mr. Webster Murnane (clerk) for the St. Martin's-in-the-Fields Vestry; Mr. T. Eccleston Gibb (clerk), and Prof. Robinson, C.E., for the St. Pancras Vestry; Mr. Cripps and Mr. Greenwell for the Marylebone Vestry; Mr. H. J. Smith (clerk)

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for the Lambeth Vestry; Mr. Harrison (solicitor) for the Bermondsey Vestry; Mr. E. Moore (solicitor) for the Great Eastern Railway Company; Messrs. Payne, Son and Pollock (solicitors) for the North London Railway Company.

WEDNESDAY, APRIL 24.

Mr. JOSEPH BROWNE MARTIN, examined by Mr. WALLACE, said that he was a director of the Westminster Electric Supply Corporation (Limited). That company's nominal capital was £100,000. All the portions of the City of Westminster had, during the course of the inquiry, been abandoned, with the exception of the parishes of St. Margaret's and St. John the Evangelist, and St. George's, Hanover-square. The capital had been subscribed for the purpose of arranging as to the purchase of sites and the fitting up of a small plant adjoining Victoria-mansions. The latter would cost about £8,000. The directors were Lord Suffield, Sir John Heron Maxwell, Mr. Henry Kimber, M.P., Mr. Hayes Fisher, M.P., and the witness. They had secured three sites for battery stations and were negotiating for two others. Two sites were wharves. Contracts for the erection of plant had been entered into with Messrs. Crompton and Messrs. Latimer Clarke, Muirhead and Co. The parishes of St. Margaret's and St. John's, Westminster, were to be lighted by Messrs. Crompton, and the parish of St. George's, Hanover-square, by Messrs. Latimer Clarke and Co. When the other stations were completed the Victoria-mansions site was intended to be used as an auxiliary. The boilers had been put down, and the dynamos and other machinery were ready for delivery, and it was expected that plant would be erected sufficient to supply 5,000 lights within six weeks, possibly within a month.

Cross-examined by Mr. PEMBER: In the case of this company there were no special patents to sell. From memory he should say there were about 20 shareholders liable to pay up the subscribed capital of £100,000.

Mr. PEMBER applied for a list of the shareholders, and after some discussion,

Mr. WALLACE said that he had no doubt that Mr. Martin would furnish it.

Cross-examination resumed:—The shares were of the nominal amount of £10 each; he held £50,000 worth himself. There was power to increase the £100,000. The £8,000 he had mentioned was for putting up the present installation for 5,000 lights. Messrs. Crompton's contract was for about half of it. The £8,000 did not cover all the contracts, others having been arranged on the basis of so much per light; he should estimate himself that 100,000 lights would cover the lot. They came out to about 35s. per light.

Re-examined by Mr. WALLACE: They did not apply for that portion of St. Margaret's Vestry that was outlying St. Georges's, Hanover-square—that is the Knightsbridge portion. The outlying part of St. Margaret's, and also St. Clements Danes and St. Martin's-in-the-Fields, were abandoned, and the Strand was abandoned.

Mr. LATIMER CLARKE, examined by Mr. WALLACE, said that his firm had erected the St. James's central station. The St. George's, Hanover-square, contract would take about four months to commence giving light from the date of getting the order to proceed, and to complete within six or seven months. They could supply 20,000 lights within four months, and another 20,000 within two months longer.

Cross-examined by Mr. PEMBER: The contract was a provisional one, and the estimates were about 30s. a light, the price not to exceed what was adjudged fair by proper arbitrators.

There is nothing to prevent an arbitrator giving a much higher sum than 35s. a light?—Most obviously. They had advised Mr. Martin that they could do the whole thing for 35s. a 10 candle-power light. His firm were to be paid in money and not in shares.

Cross-examined by Mr. MOULTON: On what system is the supply to be given?—It is the ordinary 3-wire system, assisted by batteries at the out stations.

Re-examined by Mr. WALLACE: If there was anything unfair to either side in the contract arranged, if there was any exceptional work, that was to be settled by arbitration—that was the nature of it.

Mr. PEMBER: He said the absolute price—the contract price—was to be settled by arbitration.

Mr. WALLACE: But there is a maximum given.

Mr. PEMBER: No, he said not distinctly. I asked him.

The WITNESS: Well, we consider ourselves bound by the maximum. In further reply to Mr. PEMBER as to the details, witness said that they had told Mr. Martin that he could erect the whole for 30s., lamps and everything, and they were prepared to do their part of it at a price which would enable him to buy his stations and complete the work at that price.

Major MARINDIN: I understand the arrangement is you have undertaken to supply for 35s.?—We have told him we are willing.

Mr. WALLACE, after some further discussion, undertook to produce the agreement. As to the Westminster portion, Mr. Crompton could be re-called on his return from Berlin if any one wished to cross-examine him. His was an actual contract, and he was actually supplying the plant now.

Mr. KILLINGWORTH HEDGES, examined by Mr. Wallace, said that he had three clients anxious to take the light—the St. Stephen's Club and two shops of the Aërated Bread Company. They would prefer to have it on the direct system with storage batteries, and that was made a *sine qua non* at the St. Stephen's Club.

Mr. FREDERICK WILLIAM ANDERSEN, examined by Mr. WALLACE, said that he was electrician to Messrs. Latimer Clarke, Muirhead and Company. The St. James's station had so far worked satisfactorily; at present there were no batteries. For the St. George's, Hanover-square, district it was proposed to have a battery supply system.

Cross-examined by Mr. GRAHAM: They proposed to use batteries as a stand-by and for regulation purposes. The battery power if called upon would supply 5,000 lights for one hour. They proposed to use E.P.S. cells.

Mr. C. A. CRIPPS said, with reference to the Strand agreement, that the only alteration of substance of any kind met the point raised by the St. Giles's Board of Works. As the agreement stood at present the Strand was to have the primary right to be supplied from Sardinia-street. They had arranged that Sardinia-street should come out of the agreement another station being substituted within the district of the Strand itself The new station was to be in Cecil-street.

Mr. MUIRHEAD was then heard on behalf of the St. James' and Pall Mall Electric Light Company. He said that he objected to the application of the London Electric and also to that of the Metropolitan. His company was started in consequence of the dissatisfaction caused in St. James's by the unsatisfactory lighting from the Grosvenor Gallery. The parish might roughly be divided into two areas—the first to the south of Piccadilly, containing all the clubs and a great many public buildings, which required long hours of lighting; to the north there was the poorer district, where workpeople would require motive power. So the St. James's Company resolved to establish two stations, the station in the southern part to be adapted specially to lighting purposes, and the northern station afterwards was to be established for the purpose of supplying motive power; but in order that it should be of use in a general system the machinery was so designed that when the current was turned off in the northern portion of the parish it should be utilised in the southern to assist the machinery in the south at the time of the maximum supply. A license was granted by the Board of Trade in December last. The St. James's Company did not intend to go beyond the boundary of the parish, and they desired to meet the whole of the requirements of that parish; and, having that object in view, they had accepted all the amendments that were proposed by the vestry. At the time the company was proposed a prospectus was sent out setting forth the objects of the company; and while the subscription list was still open the Grosvenor Gallery Company—he had no doubt to protect their own interests, and to try and prevent the successful floating of the St. James's Company, which was going to be a competitor—issued a map covered all over with red patches to show that the ground was practically occupied. This, however, did not affect the floating of the company. £28,000 was subscribed in the first instance, and the number of shareholders on the list was about 60. The company then purchased the site in Mason's-yard, the cost of which was £9,500. They then spent in the construction of the building £8,500, and entered into a contract for the supply of machinery for 10,000 lights at a cost of £18,500. This contract was divided into two sections, the first for 5,500 lights for £11,000 and the second making up the lights to 10,000 for £7,500. The first portion of the contract was now practically completed, and the company was now about to lay down the first section of mains, the system adopted being the low-tension system, and the machinery being divided in a similar way to that of the Metropolitan Company in Whitehall. The system of distribution was the three-wire, and they proposed to establish a network of mains through every street in the southern half. There would be a ring main running down St. James's-street, along Pall Mall, up Regent-street, and along Piccadilly, and this ring main would be connected by means of feeders with the station. He did not think it would be necessary for him to call any scientific witnesses, as the system was well known, and beyond minor matters of regulation he did not think possessed any novelty.

Mr. EUSTACE BALFOUR, examined by Mr. MUIRHEAD, said he was the chairman of the board of directors of the St. James's Company, and was an architect by profession. His company had acquired the freehold of the site of their first central station in Mason's-yard, the capacity of which is for 35,000 10-candle lights. With accumulators he was informed the total capacity would be 80,000 lights as a maximum. They had actually commenced operations, and had lighted one club with a temporary main very satisfactorily. The system was the three-wire low tension, with an average voltage of about 110. The district was a good one, being full of the best clubs and the houses of a great many rich people, the War Office, large banks, important hotels, one or two large concert halls, and very rich shops—a district where one might expect almost every building to require the light, and in many cases at especially late hours. It was proposed to connect the system of the northern half and southern half of the district, so that a total breakdown would be practically impossible. They had no transformers, but they proposed eventually to use storage batteries.

Cross-examined by Mr. PEMBER: Their nominal capital, subject to increase, was £100,000, of which £28,000 is at present subscribed. His co-directors are Mr. Hemmerde, Mr. Kirby, Colonel Francis, Mr. Royds, and Mr. Latimer Clarke.

Mr. JAMES HEMMERDE, examined by Mr. MUIRHEAD, said he was a director of the St. James's Company. About £10,000 had been paid for the freehold of the site of their station, the building contract £8,000 odd, and the machinery erected and in course of erection cost £11,000. They had deposited £2,000 with the Board of Trade, which is released in sums of £500 as the mains are laid. They had secured further capital in the form of debentures to the extent of £25,000.

Cross-examined by Mr. PEMBER: All the directors, with the exception of Mr. Royds, hold £1,000 worth of shares each. There were about sixty shareholders. He had not got a list of their names with him, but could produce it.

THE CASE OF THE VESTRIES.

Rotherhithe Vestry.

Mr. STOKES, in addressing the Inspector on behalf of the Vestry of Rotherhithe, said the objections of the Vestry of Rotherhithe were very few, and there was really not much opposition to them, if any. The first objection the vestry had was to placing any mains above ground, along, over, or across any street. They thought that overhead wires were dangerous, and should not be sanctioned. In the second place, they thought they were not sufficiently protected in cases of breaking up streets for the

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laying of mains. They also thought it objectionable that the undertakers should have power to interfere with or alter the position of any pipes already under the street belonging to other companies. They objected, in the last place, to the short notice of forty-eight hours for the commencement of works in the streets, and would suggest that not less than fourteen days' notice should be given. The vestry did not object to the preamble of the order, to the general principle of the order, and they only required protecting clauses with reference to taking up streets, the making of sewers, and most particularly overhead wires.

Mr. GEORGE LEGG, examined by Mr. STOKES, said he had been the Surveyor of the Sewers to the Vestry of Rotherhithe for thirty years. He thought that the clause enabling the company to interfere with or alter the position of any pipes or wires in any street belonging to other companies would be very objectionable. The general surface of the parish of Rotherhithe is much under high-water mark.

Mr. EDWARD THOMAS, Surveyor of Roads to the Vestry of Rotherhithe, was shortly examined on the same point, after which

Paddington Vestry.

Mr. NASH said he proposed very shortly to state the views of the parish of Paddington. He did not propose to deal with the systems of the companies applying for orders over his district, but would adopt without repeating them the arguments of the other counsel who opposed. They had not had evidence of any great demand for the electric light in Paddington, and he thought that was a cogent reason why no power should be given to companies simply to enable them to experiment in the locality at the expense of the inhabitants. In the case of Paddington there was the special objection against the proposed orders that the vestry were anxious to take the lighting of their own area into their own hands. The matter had for some time been under their consideration. Some months ago they instructed Prof. Forbes to consider the question of themselves lighting the area, and they had had a very full report from Prof. Forbes* pointing out the cheapest and most effective way of carrying out the lighting, and also stating the advantages which would accrue to the neighbourhood if the vestry themselves obtained the power. The argument, then, came to this:—That it would be better, having regard to public convenience and the convenience of the neighbourhood and the public in that locality, that powers should be granted not to two companies, not to a single company, but to the authority in the district, which could more cheaply and more effectually, and generally in a better manner, administer to the wants of the neighbourhood. The Inspector might think it well to recommend that some limited time should be given to the vestry within which they should signify their intention to apply for a Provisional Order, and that any powers granted to the companies should be subject to that condition.

Mr. FRANK DETHRIDGE, Vestry Clerk of the Parish of Paddington, examined by Mr. NASH, gave evidence in regard to the wish of the vestry to do their own lighting.

Prof. GEORGE FORBES, examined by Mr. NASH, said that several months ago he was requested by the Paddington Vestry to advise them as to the advisability of their undertaking the electric lighting of their district, and made a report to them on the subject. He thought with underground mains any company starting to supply continuous-current arc lights would certainly have to charge above £30 per light per annum for the number of hours they are used, whereas the vestry could do it themselves for about £20. As to domestic lighting, taking 15,000 16-candle lamps—real 16-candle lamps, not nominal—the cost would come out to 4½d. per Board of Trade unit. The labour under a vestry would be much cheaper, and they would also have no dividends or directors' fees to pay, besides being able to utilise dust-bin refuse for fuel, which would save an expenditure of over £1,000 a year which is at present expended upon getting rid of that refuse. He estimated the capital expenditure of the Vestry on the necessary works would be £95,000 roughly.

Cross-examined by Mr. MOULTON: He was not aware that one of the companies to whom he was consulting engineer was applying at the time he was consulted by the vestry. He did not consider the present furnaces burned dust-bin refuse satisfactorily. He was the first person to start a central station in London—it was in Haydon-street, Regent-street, for the British Electric Light Company in 1882. It was stopped by injunction six months after it started. When he said the cost of street lighting would be £30 to a company and £20 to the vestry he was comparing the regular charges, taking arc lighting on a continuous-current high-tension system. For the £30 he had taken the cost at Taunton and Bath, and added the difference of cost between overhead and underground wires, and it came to £30. The charges for arc lighting are usually made at so much per annum on so many hours' lighting.

Cross-examined by Mr. C. A. CRIPPS: He was not aware that dust-bin refuse had been offered to the Metropolitan Company and £2,000 a year in addition if they would get rid of it. He had not heard there were no furnaces which could deal with it. He did not know until the day before he delivered his report to the vestry that Paddington was included in the area of supply of the Metropolitan Company.

The Strand Vestry.

Mr. H. L. CRIPPS then addressed the Inspector on behalf of the Strand District. He said that under the Act of 1888 it was expressly provided that no Provisional Order authorising electric lighting should be granted by the Board of Trade except with the consent of the local authority, unless the Board of Trade in any case in which the consent of the local authority is refused are of opinion under all circumstances that that consent ought to be dispensed with. This responsibility cast upon the Strand District induced them very seriously to consider the whole question of electric lighting in their district. There were five companies making application for Provisional Orders, and the first thing the Strand Board set to work to consider was whether any, and if so which company, was in the best position, financially and generally, to merit their support. The result of a great many interviews and much correspondence was the form of agreement which has been referred to as having been arrived at between the Strand District and the Metropolitan Company.

THURSDAY, APRIL 25.

The Inquiry was resumed on Thursday morning, and the case of the Strand Vestry was proceeded with.

Mr. H. L. CRIPPS said: With regard to the agreement between the Strand Board of Works and the Metropolitan Company the points gained in it were first, the definite appropriation of the different stations as the source of light in the district; second, the definite allocation for distributing mains throughout the entire district in positions satisfactory to the local authority; third, the security that from these stations and mains an adequate supply of electricity will be produced for the district; fourth, an easy means of detecting the cause of any failure or deficiency in the supply of the district; fifth, an easy access to head-quarters, situated in the district, to lodge complaints and obtain a remedy; sixth, definite arrangements for preventing obstructions in the streets; seventh, the relief of the Board of Trade from the task of arbitrating between the local authority and the company with regard to works in the streets; eighth, freedom of the consumer from various onerous conditions with regard to his obtaining a supply, and arbitrary powers contained in the Provisional Order; ninth, a system which augurs as fairly as possible for a harmonious working between the local authority and the company. These points he claimed to have gained under the arrangement. There was one other point—that of friendly competition—which had been put forward mainly on behalf of the London Electric Supply Corporation. In the Strand it was especially important, because at the most they could not find room for more than two sets of mains. Therefore, when the London Company asked to be admitted as well as the other company with whom the arrangement had been come to, it followed that between them they would have an absolute monopoly in the Strand. Under the express provisions of the Act of last session the Board of Trade could hardly without strong cause shown override the consent of the local authority. He assumed the Inspector would agree with him in thinking the Provisional Order of the Metropolitan Company ought to be granted. Then came the question whether, in addition, the powers should be conferred upon the London Company. The Strand Board felt that the consent to the London Company's order ought to be withheld. It was obvious that the dealing with the jointed mains must involve more street disturbance than the system proposed by the Metropolitan. In a main seven miles long, in pieces of copper conductors about 21 feet each, there would be something like 1,760 joints. The mere question of the expansion and contraction of copper offered in itself a difficulty; its advantages seemed to him to be the less cost of coal and supervision and the removal of smoke from London. Examination of the Whitehall station had satisfied his clients that there was no objection on account of smoke; it did not seem to him that the production of the 120,000 lights for the Strand would cause any appreciable difficulty in regard to smoke, coal, &c.

Mr. G. H. COLE, examined by Mr. H. L. CRIPPS, said that he was a member of the Strand District Board of Works and a member of the Electric Lighting Committee of that Board. The opinion of the committee was that if the Metropolitan Provisional Order was modified in accordance with the agreement it would afford a satisfactory solution of the electric light question in the district.

Mr. PEMBER: Now, for instance, take clause 8, which fixes the price. That is completely against what Parliament has hitherto considered the proper policy, is it not?

Mr. C. A. CRIPPS: That is a matter for argument.

Examined by Mr. HUNTER: The eight conditions were not sent to the Storage Company. He believed that when the applications were first made for licenses the Storage Company was one of those which was put aside as not satisfying the requirements of the committee.

Just let me ask you this. Before you determined to confine the competition to the London Electric Light and the Metropolitan Companies had you made any inquiries as to the systems of lighting which these companies proposed?—I am not aware that we did.

Did you know what was the system proposed by the Metropolitan, and had you compared it with the system proposed by the Electric Storage Company?—No, I believe not. As to electricity being supplied for use in motors, the witness continued that the committee only dealt with lighting. They did not go into technical matters, but they saw that the system of the company selected was in perfect working order by the example of the Whitehall-court station: they knew there would be no storage in the system applied by the Metropolitan Company to the Strand. From what the committee had learned of storage it certainly did not in any way meet with their approval. By the agreement as originally settled both generating stations were outside the district of the local authority.

Now do you consider the bearing of that fact upon the provisions of the Act which enable the local authority at the end of 42 years to buy the plant?—I do not think that point perhaps was considered.

Of course you must see that at the end of 42 years if you deal with the company which has its generating stations outside the area that all you can buy will be the pipes and mains.—The WITNESS: Why not the tation?

Because it is outside your area.—Why not purchase that as well as that which is within your area?

You can purchase voluntarily of course, but I am speaking of the compulsory powers to purchase supposing they did not want to sell.—It is the company's property.

Major MARINDIN: That is a matter for argument.

Re-examined by Mr. H. L. CRIPPS: At the inception of this matter the witness himself was a very stout advocate of the London Company that they should have a fair hearing.

* See *The Electrician*, April 12, p. 658.

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Wandsworth Vestry.

Mr. R. W. YOUNG was then heard on behalf of the Wandsworth District Board. He did not for one moment say that the Metropolitan Company was deficient in capital, but suggested that the Board of Trade should consider whether there should be a deposit or further capital raised in the way that was provided in the St. James's order. They also wanted a clause to prevent the buying up of any competing company in the future, and there should also be a limited area for the location of the generating stations. They thought some sliding scale should be incorporated in the order. With regard to price, they suggested that instead of 8d. the same price as in the St. James's order, 7d., should be inserted.

Mr. ARTHUR SOUTHAM, the Wandsworth District Surveyor, was briefly examined in support of Mr. Young's statement.

St. James's Vestry.

Mr. WILKINS then addressed the Inspector on behalf of the St. James's Vestry. He said that his observations would be addressed to the cost to be actually paid by the consumer for the current he obtained from the company. They had already consented to two or three orders and licences, and up to the present year not one of them had ever actually come into operation. In fact, he might say that the supply of electricity under the statute did not commence, as a matter of fact, until this inquiry had actually been opened. So far back as 1883 he represented the vestry before the Board of Trade, and they had come to see, he thought, that the views entertained at first by the local authorities, although perfectly legitimate at that time, seeing the utter absence of reliable information, were somewhat extreme in the light of the present condition of the science of electricity. On the other hand, the companies had advanced and met them in a much more generous spirit than they were disposed to do in the early days of the movement. The first question of policy was whether they should adopt a system of free trade or of districting. His district had large clubs and mansions, all of which might be expected to be large consumers of the current; but they had also the back part of the parish, in which the supply of electricity for lighting purposes at anything approaching its present price would simply be prohibitory. But that district was largely dotted with manufactories having small mechanical appliances - small gas and small steam engines—and that they did not view with any great satisfaction, but would be exceedingly glad to see the introduction of electricity for the purpose of power. As to the question of free trade *versus* monopoly, he did have some intention of calling Mr. James Beal as a witness, whose investigations in connection with the gas monopoly, and the eventual legislation resulting in the districting of the companies, were pretty well known, but his evidence would have been little more than a digest of official documents already in the possession of the Board of Trade. The vestry had adopted—on very common-sense grounds, he thought—the principle that districting was as essential in the case of electric lighting as it ever was in the case of gas; and more so, as in the first case the ground was now occupied by mains—there were no less than 15 companies at the present time having authority to lay mains along Regent-street. The present uselessness of many of these mains were largely due to the mistaken policy of free trade in gas in the early stages. If two electrical companies each of them laid a main at a cost of £100,000, and one main would suffice, then who would bear the loss? Well, to some extent that might be met by competition. But let this be remembered, that the electrical lighting companies are protected by a guarantee of 20 per cent. on the cost of their mains, whether they were necessary or unnecessary, for a period of three years.

Mr. LOYD: We do not assent to that.

Major MARINDIN (to Mr. Loyd): You can remark upon that.

Mr. WILKINS: Of course if the competition were equal, supposing the companies supplied each of them their 50 per cent. of the current from the main, no doubt competition would then be operative; but supposing we take it that there is a powerful company supplying 90 per cent. of the current for which the main was laid, and the other simply supplying 10 per cent., the condition of competition would then be absolutely unfair and unequal. He thought that the evidence of Mr. Ferranti would show that practically the whole system of the London Electric Supply Corporation was experimental: the dynamo that was to be constructed was to be very much larger than any that had yet been erected. The rigid concentric main was to be jointed at every 20 yards, and it was admitted that at every 20 yards there would be the weakest part of the system. There was, in addition, the potential of 10,000 volts, which had never yet been attempted even on a small scale, and here the experiment was to be made for a distance of seven or eight miles. The conversion was to some extent an experiment, and the question arose whether it was wise to entrust this company with so large an area to make their gigantic experiment upon. After prolonged inquiry and negotiation the vestry had adopted two competing companies—the St. James's Company using the continuous current at low-tension, and the Metropolitan Company which was doing work in the parish at a moderately high-tension on the alternating system. So they had adopted a middle course—they had neither gone in for free trade nor for districting, because, while they agreed with the districting they did not think that the time was yet arrived when a fair scheme of districting could be laid down. After reviewing the question of overhead wires, Mr. WILKINS said that it was important that they should have a system capable of supplying the current for motors. Taking Mr. Ferranti's evidence, that as a commercial matter a motor with an alternating current was absolutely unknown in England, that was one very fatal objection, in the opinion of the vestry, to granting to the London Electric Corporation an order which from the vastness of its operations would probably very soon result in a monopoly. Another objection was the high potential, and they were not satisfied with regard to the insulation. It was claimed for the Deptford scheme that there would be a net economy in cost of production of 43 per cent. One would have thought that at any rate the consumers would have part of the benefit, but he found that the London Company sought power to charge 8d. per unit, whereas the maximum of the two companies who had assented to the terms of the vestry was only 7d. He proposed to re-call Mr. Swinburne on a new point.

Mr. JAMES SWINBURNE, re-called, examined by Mr. WILKINS, said he thought that there might be a saving of two or three shillings per ton in coal at Deptford, but he thought that the Metropolitan Company at Waterloo would be on the same footing. With reference to Mr. Ferranti having said in his evidence "our coal is half the price," that seemed to the witness to be too large a reduction by far.

WITNESS continued that he considered that the saving in superintendence in the Deptford scheme would be little or nothing, as the superintendence required at the distributing stations would counterbalance it.

Mr. WILKINS: Mr. Ferranti gave in his evidence that the proportion of the cost of bringing the current up from Deptford would be 7 per cent. to £100 on the capital outlay at the generating station?—Yes, I remember the figure.

You have seen the models of the main?—I have.

Then, taking the mains as given by Mr. Ferranti, what do you estimate the cost of one main from Deptford for seven miles, the hypothetical distance, would be?—It is rather difficult to estimate it; £14,000 is a very low estimate indeed. I have got here a piece of cable of the same area manufactured by the Silvertown Company, who are one of the leading cable companies. It is an India-rubber insulation, it is the same area, and the price is £2,500 a mile; but if you insulate it outside as well it comes up to £5,000 or £6,000 a mile. That is an extreme case, because the insulation they would put on would be probably better than the London Electric Company would require; but I think you may take it that £14,000 is rather too low a figure.

That is £2,000 a mile?—Yes.

Taking the cost of a station of 100,000 lights, and the cost of distribution at £150,000, what percentage do you make the cost of mains bear, to work out somewhere about 18 per cent.?—Something of that sort—nearly 20 per cent. instead of 7 per cent. The witness continued that he did not think the saving in going to Deptford would be anything like 50 per cent. He did not anticipate any nuisance from steam from local stations.

Cross-examined by Mr. GRAHAM: There was not much difficulty in making a small alternating current motor up to one horse-power, but when you got to large motors the difficulties would be very great. He was making a small quarter horse-power one himself, but there were great difficulties to be overcome before he could make it commercial.

FRIDAY, APRIL 26.

St. George's, Hanover-square Vestry.

Mr. JOSEPH HENRY SMITH, Vestry Clerk of the Parish of St. George's, Hanover-square, examined by Mr. HITCHINS, said there were four companies making applications for Provisional Orders in St. George's Parish—the London, the Metropolitan, the Westminster, and the Chelsea. Taking the London as a standard, their principal objections to the orders were—the length of time for compulsory works, which they thought should be reduced to eighteen months, the placing of overhead wires without the express sanction of the local authority, and the penalty clause. The next serious objection they had was with regard to the power which was proposed to be given for the suspension of the order by the Board of Trade. There were various other questions which the vestry considered material to be altered, but at the same time they were not of vital importance. Subject to amendment in these respects the vestry had no objection to the orders of the London, the Metropolitan, and the Westminster. Copies of the amendments suggested were sent to the Board of Trade and to the companies. Subsequently a letter was received from the London Company, on which the vestry passed the following resolution:—"That the vestry do now approve of the application of the London Electric Supply Corporation (Limited) for a Provisional Order to enable the corporation to supply electricity in this parish, but upon the express condition that the corporation accept all the alterations and conditions which have been insisted upon by the committee acting on behalf of the vestry, and that the order should be so amended as to clearly and distinctly embody the same." A similar resolution was passed with regard to the Westminster and the Metropolitan. With regard to the Chelsea Company, the vestry objected from the first to that company coming into the parish.

Cross-examined by Mr. MOULTON: The objections to the Chelsea Company were formulated in writing and sent to the Board of Trade. The main objection was that it did not undertake to light the whole of the parish.

Kensington Vestry.

Mr. HEWITT then addressed the inspector on behalf of the objections of the parish of Kensington. When the Kensington Vestry first considered the question of electric lighting there were six companies competing—the Metropolitan, the London, the Notting Hill, the Kensington and Knightsbridge, the House-to-House, and the Chelsea. The vestry immediately appointed a committee, the chairman being Mr. Jordan, and one of the most influential members Mr. Saunders, Q.C. The committee met the various representatives of the companies, and the whole matter was thoroughly discussed. The matters under discussion were the area of each company, the system of laying mains, the maximum charge to customers, whether smokeless coal would be used, as to laying underground wires, the system proposed to be adopted, and whether the companies objected to having wires in the same conduit as other companies. The House-to-House Company were willing to light the area pointed out as allotted to them; would lay mains in pipes near the kerb in footway, diameter of pipe to be 6in., and would put themselves entirely in the vestry's hands with regard to the method of laying mains. The varying scale of charges would be—first 100 hours 1s. per unit, second 100 hours 8d. per unit, third 100 hours 4d. per unit; could give light in any part of area in two months; vestry to have the right of purchase in 21 years, under the usual arbitra

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tion clause. The Chelsea Company would not make a varying charge—the maximum would be about 8d.; would give vestry power of purchase in 21 years in proper arbitration clause. The Kensington Company would fall in with the views of the vestry as to the system of laying mains; the maximum charge to be 8d. per unit; would use smokeless coal; could not say positively, but was of opinion that they would give the vestry power of purchase in 21 years. The Notting-hill agreed in the main to the conditions of the other companies; maximum charge to be 8d. per unit; would adopt a sliding scale if found workable, and would sell to vestry in 21 years. The Metropolitan Company and the London Company withdrew their applications. He would say with reference to the question of generating stations that it was eminently desirable that in all cases before stations were created the sanction of the local authority should be obtained. He thought it was especially desirable in a large residential parish like Kensington, where property might be very seriously injured by the erection of works for the supply of electricity. The companies who propose to supply Kensington must not be looked upon as benefactors, but simply as speculators—speculators no doubt engaged in a very lawful and legitimate enterprise; but he ventured to think that the proper thing to do was to have regard to the views of the local authority in matters of this kind.

Marylebone Vestry.

Mr. H. L. CRIPPS, on behalf of the parish of Marylebone, said it appeared to the parish that the application of the London Company should not be granted, because, under the present scheme, Marylebone would be upon the extreme outskirts of the area of supply, and after all the evidence which has been given as to the possibility or feasibility of the London Company's scheme, it seems obvious that the position of Marylebone might be one of very doubtful advantage. The scheme which the London Company have adopted will entirely defeat, when the time comes for its operations, those provisions of the Electric Lighting Act which enable the local authority to acquire the undertaking. As regards the various questions which have arisen as between the local authorities and the companies, the parish of Marylebone has been approached by the Metropolitan Electric Light Company with suggestions for an arrangement which appears, so far as Marylebone is concerned, to be satisfactory to the authorities. They have come to an arrangement with the parish of Marylebone, which is now embodied in an amended Provisional Order which has been prepared. He could hardly say he was in a position to hand it in at the present moment because it had only reached his hand this morning, and of course requires very careful revision on behalf of the parish. Under it the Metropolitan Company come to an arrangement under which they are to provide within the Parish of Marylebone a station which shall be sufficient for supplying light to the parish. Much in the same way as with the Strand District, they are to lay down within a definite period a sufficient number of mains, on the assumption that they will be the parties in the first instance alone entitled to deal with the parish; and on that assumption they have agreed to a similar provision to that which had been arranged in the Strand case, under which the price to be charged in the first instance is to be substantially the same, but somewhat lower than proposed by the Provisional Order, and under which, at the expiration of every period of seven years, that price is to be subject to a revision by an arbitrator. Of course it is obvious that the parish of Marylebone differs very much from the Strand District; it is true that it is occupied by persons who may be expected to a large extent to be customers for the electric light, but it is equally true that a large part of the Parish of Marylebone is sparsely populated and inhabited by a class who would, at all events, not be customers. It could hardly be expected, therefore, that any electric light company would place itself with regard to the whole of the parish under conditions quite so favourable to the consumers as those which apply in the Strand District. As regards a great part of the parish of Marylebone, the Metropolitan Electric Lighting Company are the only applicants, and as regards that part, therefore, their application is unopposed. With respect to the southern part of the parish, however, the London Electric Company are also applicants. He said that if the Board of Trade sanctions the order applied for by the London Company as far as regards parts of the parish of Marylebone, it would certainly operate in a way which seemed to him to be very inequitable, unreasonable, and inconvenient to the parish. If it were granted the effect would be that the Metropolitan Company would be placed in competition as regards the best part of the district with the London Company. Therefore, on behalf of the parish of Marylebone, he would ask that, subject to the terms of this arrangement being carried out, the Inspector would recommend for acceptance the Provisional Order of the Metropolitan Company.

Mr. WALPOLE EYRE GREENWELL, examined by Mr. H. L. CRIPPS, said he was the solicitor for the parish of Marylebone, and had been many years vestry clerk. Electric lighting had received the very careful attention of the vestry, and the question had been submitted to a committee of the vestry. The arrangement arrived at by them was one which was thought would be very advantageous to the parish of Marylebone.

Cross-examined by Mr. PEMBER: Some months ago representatives of the London and Metropolitan Companies attended the committee of the vestry, and their views were well considered. Negotiations took place with the Strand Board of Works with regard to certain terms for forming an agreement for the admission into the Marylebone parish of the Metropolitan Company. The London Company did not propose any terms which would modify the terms of the proviso. He had proposed to the London the same terms as to revision of prices as he had to the Metropolitan. He had told the London, "If you put your alterations before us we will consider them." The terms proposed by the Metropolitan Company appeared to be satisfactory to the committee, but there were no definite terms proposed on behalf of the London. He believed he told the representative of the London Company what the terms with the Metropolitan were—he was certain he did so as to revision of price, and he believed also as to the other terms. At the date of the arrangement, if the London had accepted the same terms as the Metropolitan the vestry would have consented to their order as well. There was a resolution to that effect of the 6th of April. It was not one of the conditions of the Metropolitan Company that they were to have the exclusive right. The vestry would not agree to it.

St. Margaret's and St. John's, Westminster, Vestry.

Mr. H. L. CRIPPS, for the vestry of the united parishes of St. Margaret's and St. John's, Westminster, said it would be observed that the geographical position of the area under the control of the vestry is rather peculiar; the parish of St. George's, Hanover-square, was sandwiched in the parish of Westminster, and the latter thus became entirely divided. However, it was not very material, as the vestry proposed to withhold their consent to any of the Provisional Orders. They had had the matter under consideration, and he thought he was authorised to say that they adhere rather to the system of one company authorised in a particular area rather than two companies being allowed to compete and place their mains in the same streets. None of the constituents of the vestry had urged the vestry to consent to any of the Provisional Orders, and, therefore, the vestry came to the conclusion that so far as the Westminster portion of their parish was concerned they might be left in the advantageous position of waiting for a year and considering in the light of the information obtained at this Inquiry what would be the best course to adopt. As regards the Knightsbridge portion of the parish, however, two licenses had been assented to by the Vestry of Westminster to one company.

After a short discussion,

St. Giles' District.

Mr. H. C. JONES said he did not propose to detain them long on behalf of the St. Giles' District Board of Works, nor did he intend to enter into any technical discussion, because he felt sure that it had already been dealt with fully. With regard to the London order, his Board had had an opportunity, through the courtesy of the company, of inspecting the works at Deptford, and had obtained all the information possible, and having regard to such information they were of opinion—for what that opinion was worth—that it is desirable that electric light works should, as far as possible, be kept out of large centres of trade and professional businesses. He considered that the public authorities should be placed upon somewhat more favourable terms with regard to public lighting than is proposed at present. Any dispute as to price he thought should be referred to arbitration. Meters, he thought, should be examined in the same way as under the Gas Acts. He suggested it was extremely unfair that one district should be placed on more advantageous terms than another, and if the Metropolitan Company could give concessions to the Strand they were able to give them to the adjoining district on either side, so far as they were of a somewhat similar character. If not, he said that virtually the ratepayers in other districts would be paying towards the electric lighting of the Strand District.

Mr. H. C. JONES then offered himself for examination, and was questioned by Mr. CRIPPS with reference to the agreement with the St. Giles' District.

Lambeth Vestry.

Mr. J. H. SMITH was heard on behalf of the Lambeth Vestry, and was afterwards cross-examined by Mr. PEMBER and Mr. CRIPPS.

St. Pancras Vestry.

Mr. COATES, in a short speech, said that the parish of St. Pancras stands in an entirely different position from any of the other parishes in London, inasmuch as they themselves had got powers under Provisional Order passed in 1883 to light the whole of the parish of St. Pancras. He thought they would be more likely to make it pay than a company would be—they would have no dividend to pay, and could raise their money at 3½ per cent. Being entirely independent they thought that no company should be introduced into their parish with powers to compete with them.

Mr. MOULTON, for the Telephone Companies, said they simply wished that London should be kept in comparatively electrical quiet, and they would only require a clause in all orders which would ensure this.

Mr. CROMPTON put in the estimate for the Westminster Company and a list of the subscribers to the capital of the Westminster Electric Supply Corporation. The subscribers are—Lord Suffield, £250; W. Hayes Fisher, M.P., £5,000; Sir John Heron Maxwell, £5,000; J. Browne Martin, £50,000; Henry Kimber, M.P., £5,000; Alfred Baker, £5,000; Edward Vigers, £5,000; J. Gunn Richardson, £5,000; R. W. Wallace, £5,000; D. P. Sheridan, £5,000; R. Fowler, £5,000; James Maclean, £5,000; David de Pinna, £5,000; John Fleet, £5,000; H. N. Newbyn, £2,500; W. H. Baker, £500; H. A. Hunt, £5: and J. W. Hiscox, £5; making in all £113,260.

Mr. RUSSELL GRIFFITHS, for the City, submitted that no Provisional Order should be granted to the London or Metropolitan Companies. Mr. Preece had described the scheme of the London as a gigantic experiment, and he (Mr. Griffiths) suggested that there was not only absolute danger, but absolute extinction of light from the insulation gradually becoming insufficient. If they could get companies to come and light the City at a cheaper rate than that proposed by the orders, he failed to see anything in the Electric Lighting Act to prevent a local authority from contracting itself out of the Act if they could get the lighting done by contract.

SATURDAY, APRIL 27.

Mr. WALLACE, speaking on behalf of the Kensington and Knightsbridge Electricity Company, proceeded to deal with the objections of the St. Mary Abbott's Vestry. As to their requiring that the undertakers should keep separate accounts, he said that although this might be necessary in the case of a large area there was no reason for it in a compact district like this. Then the vestry required a restriction as to overhead wires. His

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company had not on any occasion placed overhead wires except within their own property, and it would be very hard that they should be open to the competition of any company coming into the district with overhead wires, and they suggested that the vestry should undertake not to allow any other company to place overhead wires; if the vestry undertook to do that his company were willing to incur penalties. The company took this very early into consideration, and came to the conclusion that it was illegal to put overhead wires within the district for which they applied. The case of the United Telephone Company *versus* The Wandsworth District Board of Works was not an authority to govern any such placing of wires as was contemplated by electric lighting companies. That case was one of a solitary wire being carried across a street, and the question really turned upon whether the local authority had any property in the air above the streets. But if that case had been fought on the question of nuisance the result would have been very different. As to the period for the commencement of compulsory works, his clients had no objection to eighteen months being substituted for the two years, and his company would be willing to agree to a clause to meet the matter of the breaking up of the streets. The next suggestion of the vestry was that prices should be revised every seven years. That would be manifestly unfair to companies who were limited to forty-two years. Then the clauses suggested by the railway companies would practically lead to the railway companies getting a monopoly instead of the electrical companies, as the Underground Railway Company, for instance, could say "No, there is already an agreement with some other company that no one should cross this railway except themselves." Next, as to the ojections lodged by St. Margaret's and St. John's. It had been said that there was no demand for the light within that district, but he had applications in his hand from Princes-street, from Ennismore-gardens, and Kensington Gore, for a very large number of lights. The vestry had resolved that it was expedient to retain the power in their hands, but no evidence had been given that the vestry had made efforts to find the necessary funds to carry it out. The Chelsea Company's station at Draycott-place lay at some distance from the Egerton-gardens portion, while that of his clients was across the Brompton-road, in the course of erection, and the light would be ready to be supplied in the next few months, or as soon as the Provisional Order could be got. The chimney had been erected, the building erected, and the boilers had been erected, but the dynamos and engines had not been put down, although they were on order, and they were starting to fix the engines that day. Sir William Thomson and Dr. Hopkinson had admitted, although they were not here to represent the Storage Company's system, that the system of the Kensington and Knightsbridge Company met with their approval, although the system of the Chelsea Company did not meet with their approval.

Mr. MOULTON: They did not say that.

Mr. WALLACE: They were called against that system, and when he examined them they made that admission.

Mr. MOULTON: They gave no evidence of that sort.

Mr. SHIRESS WILL then addressed the Inspector on behalf of the House-to-House Company, chiefly as to the settlement of certain details of boundaries between the neighbouring companies.

Mr. WALLIS, on behalf of the Westminster Electric Supply Corporation, said that his was a company in an analogous position to the Notting Hill Company, but was a company which had certainly done more than the Notting Hill Company, inasmuch as it had chosen sites and had used a certain amount of preliminary capital in erecting a station with 5,000 lights. He had handed in a list of shareholders, and among the names would be found those of responsible men who could subscribe the amount standing against their names. Now how had the London Company gone to work? They first of all started in the Grosvenor Gallery and commenced to lay down an installation which, on their own admission, they had to abandon. Another use they made of their capital was to commence a system of overhead wires. That capital, according to their own confession, was wasted and had to be abandoned. Then again, they did not think of applying for a Provisional Order, but attempted to seize on certain portions of London in an illegitimate manner. What it amounts to is this—the London Company say their station is to supply a large area of London, and, although they gradually abandon portions of the area, they say this is to light London. They spend their money, they erect the station, they lay down the plant—and on what security? None whatever; and that is the way these gentlemen deal with the money they have taken from the shareholders, instead of waiting to see whether they will get their Provisional Order or not. Are these gentlemen to be trusted to look after the affairs of the company or the lighting of London? I say no, sir. I am convinced you will say no, sir, and that the Board of Trade will say no. Sir William Thomson, who was here as their witness, says their system is an experiment, and I will leave it there. Now, leaving the London Company, let me consider what position we are in with regard to the local authorities. St. George's, Hanover-square, say they are satisfied with this Westminster Company, and it is to the local authorities that you must look to investigate these matters, and not to the rival companies, who, when provoked, say nasty things one against the other. With regard to the vestry of St. Margaret and St. John, Westminster, they have refused all companies alike. We abandon the Strand, St. Martin's, and all those places where we come in contact with the Metropolitan Company and the E.P.S. Company.

Mr. MOULTON said that in the cases of the two companies he represented there was almost every variety of the problem which is now before the Inspector. In the case of the Chelsea parish he represented a company that already had a Provisional Order, and had begun to work under it. In the case of the piece of the South Kensington area which was sought to be added to the Chelsea area, he thought that an application in a parish in which the local authority had gone most carefully into the matters, and had laid before the Board of Trade some exceedingly important recommendations, was indicative of the great care and thought which had led them to advocate a strict system of districting. As regards capital, the whole question was gone into by the Board of Trade in 1883, when the question of Provisional Orders came up, and he thought the conclusions he came to, after much patient thought, were very sound, and needed no departure from at the present time. The substance of those conclusions was this—that a company must satisfy the Board of Trade that it had proper and sufficient capital to do its work, must appropriate it to local use, and in all cases put down a portion of that capital as a guarantee that it did not idly take up the obligations of its order without any substantial intention of carrying them out. He thought that the question of satisfying the Board of Trade that sufficient capital was appropriated was not a matter to be done at this Inquiry; but at the moment the Board of Trade called such evidence, both his companies were in a position abundantly to satisfy the Board of Trade. Indeed, he might say for the E.P.S. Company they had already satisfied the Board of Trade of their financial strength being sufficient for the obligations they proposed to undertake. With regard to what had been said of the intention of the E.P.S. Company to obtain an order for themselves and to transfer it for a profit, it would be open to the Board of Trade to keep the E,P.S. Company as the undertakers. They had accepted the position as undertakers.

Mr. MOULTON had not concluded his address at the adjournment of the Inquiry.

The following estimate was put in by the Westminster Electricity Supply Company:—

Estimate of Generating and Distributing Plant.

2,880 horse-power of Babcock and Wilcox boilers, 8-feed water heaters, including fixing and setting, but no brickwork	£9,148
2,880 horse-power Willans engines, including bed-plates for the dynamos, all electric governors and other adjuncts, fixing in place	14,000
All steam and exhaust pipes and connections, all feed pumps, water tanks and water connections, fixing the whole	4,500
16 110-unit dynamos, each to give a current of 500 amperes at an E.M.F. at the terminals of 240 volts, including fixing automatic cut-off switches, complete	12,400
Switch-boards, regulating apparatus and instruments for the generating and distributing station	3,000
Accumulator plant, consisting of 252 73-plate accumulators, each provided, in metal lined cells, with cast-iron stands, insulating trays, and all supports and accessories	7,350
Travelling crane and workshop tools	350
Total for generating station	£50,748

Distributing Plant.

Mains:—Victoria-street, 2,000 yards of culvert; Whitehall, 600 yards of culvert; York-street, St. James's-street, Buckingham Palace-road, 1,300 yards of culvert. Including all surface boxes, bare copper main insulators, straining connections	9,500
Batteries, switch-boards, and regulating apparatus at distributing station, Buckingham Palace-road	4,900

MONDAY, APRIL 29.

Mr. MOULTON, continuing his speech, said there was not the slightest intention on the part of the E.P.S. Company of any sale or any transfer of one shilling of the profit. The subscribed capital would be tied up strictly in the way the Board of Trade think it desirable to tie it up, and it should not be thought for one moment that this was an attempt to get an order and make a traffic in it or transfer it in any sense. The precedent of the transfer to which he had referred was the following:—In 1883 the Crompton-Wingfield Association applied for two or three orders, and before the orders came on they formed a company. He did not know whether there was any subscription, but they formed a company named the Incandescent Lighting Company, and orders were granted to the Incandescent Lighting Company, even though all the notices had been given by the Crompton-Wingfield Association. What the Board of Trade did then was to look at the substance of the matter instead of the form. They required to be satisfied that substantially the application was to be carried out by the same persons by whom it was substantially made, and that these persons were prepared to put down the money to secure it, and then as soon as they were satisfied of that they took no further notice on the point. A similar case occurred in the case of the Chelsea Company. There the notices were given by four private persons. Before the order was actually passed into law the Chelsea Company was formed, and they are the undertakers under the order. He thought the real thing was to find out that there is capital which will be appropriated to the working out of this order, and that the persons who are going to work the order are persons who are of such standing as may be trusted with it. Now on this point he believed the Board of Trade were already satisfied; but if not, they should be satisfied in any way that they might desire by his clients. In referring to the question of system, and how the transformer system affects the need of further provisions, or justifies a relaxation of the model order, he should submit that so far from justifying any departure from the model order it only emphasises the importance of the prudence of the obligations under that order. He should put before the Inspector that still the direct supply beyond question was the best for the consumer, and that if the direct supply is to be given, and given effectively to the public, all the obligations of the model order should be insisted on, and he was sure they would be cheerfully borne by all those companies who wished to do their duty. The transformer system differs from the direct supply in that the natural inducements to do its work thoroughly and make electric lighting a thing used from house to house are absent. The London Company seemed to him a company that had seized on the one great feature of the transformer system, namely, that it would enable them

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to hold the City so that no competitor could come in, without really giving to the public electric lighting in the best way; and under the guise of "Down with monopoly" he thought they were asking the Board of Trade to sanction an attempt which would leave London (if it were successful, which he trusted it would not be) as much at the mercy of a large corporation as it has hitherto been at the mercy of the gas and water companies. For motive power the direct supply was the only form of supply that could be used. Now is motive power an important thing? Lord Crawford, who represented a company which admits it cannot supply electricity for motive power, said that he believed the demand for motive power would considerably exceed that for lighting. There were signs of that already he (Mr. Moulton) thought in the increased demand for gas as a motive power, which, on account of the skilled labour required, and other things, was placed at a great disadvantage compared with electricity, a power so simple that the least educated man could use it without any previous training, and so free from objectionable element that it could be used anywhere from the parlour to the workshop. It had been suggested that one or more persons had solved the difficulty about the alternating motor, but to his mind it was all in the air. The transformer system was a thing which proposed to bring into every house electricity under circumstances in which it would be dangerous to life and property if there was from any reason an escape. He quite admitted the value of the safeguards against danger, but it still remained true that electricity was brought into houses under dangerous circumstances in a way in which he could not see that one could prevent imprudence or carelessness from making that danger a very probable one. He could not see that the transformer system was a cheaper one—nobody had brought figures to show that it was cheaper. Where was the advantage of the transformer system? It had been applied in 120 places in America, and in several places, apparently, on the Continent, and it was now being applied in England. The evidence of Mr. Knight had not been contradicted. It was that when you had got straggling areas the transformer system was the best, but nothing had yet contradicted the notion that the direct supply was cheaper where you had not straggling districts; and the question here was of districts of a manageable size. That was the real question the Board of Trade would have to decide. Were they going to say that now, when it is practicable to pick up the plums of a large area—were they now going to relax the very regulations which the fear of that being done made them put into the order of 1883? Now, dealing with the question of the two methods, he thought he was justified in taking the case of the London Company. He admitted that it differed from the Metropolitan. The Metropolitan was a company which was wanting to get as many areas as it could. Whether it would do them was another matter. It boasted enormously of its capital. It talked about half a million subscribed, and it turned out that at six stations they had already committed themselves to £350,000, so that they had only £150,000 left for the enormous area beyond. If its capital was compared with the area it was applying for, instead of being a rich company it was the most miserably poor company which had come before the Inspector. Even the London Company asked for only something like two-thirds of what the Metropolitan asked for, yet it had got a capital of about two and a-half times the size. The London Company had pushed the transformer system to its legitimate consequences as far as electrical engineering was concerned, made it possible to pitch upon any portion of their enormous area and light that from Deptford. Supposing they got their area they would be able to do the best piece of the City for its day lighting, the best piece of Chelsea for the purpose of strangling the Chelsea Company, the best piece of the Strand and of Marylebone. They had adopted the system which would enable them to take the plums, and they asked for a large enough slice of London to give them sufficient plums. Now he wanted to contrast the aims of the Board of Trade in 1883, and their means of carrying them out, with what were the aims of this company, and their means of carrying them out. The object of the Board of Trade was not to let a company have powers over a district unless there was a reasonable certainty that they would put the electric light within the reach of the whole of the people in that district. The "B" districts were only with great difficulty accorded to the companies, and the only reason why the power of extension was given to the companies was this—that if they took the pioneer risk it was just to give them the opportunity of a moderate extension without the expense of further application to Parliament. But the Board of Trade knew that those companies' only object was to develop electric lighting; they had no opportunity of picking out plums, and they required the allocation of capital; and, above all, there was the clear understanding that they were not statutory monopolies—that if they did not succeed in doing their work other companies would be allowed to come in, and that they embodied in the well-known clauses of the model order. He accused the London Company of deliberately intending to do the plums. If he was right those clauses must have made the London Company wince, and those clauses were left out. Were they or were they not to begin with compulsory mains? What did the London Company propose to do in the way of actual works? Not one single yard of main did it undertake when it lodged its order. They now undertook to do in Chelsea the same compulsory mains as the Chelsea Company undertook to do in 1886 in order to get their small area. The London Company had 16 square miles of London, and yet this was the only compulsory obligation they took upon their shoulders. It was to give a mock appearance of equality with the Chelsea Company. If an obligation the same as was put on the companies under the model order of 1883 was put on the London Company, where would their capital be? Their capital was big enough to hold London—but not to light it. The 250,000 candles they admitted would be just about big enough for a quarter of a million of people. Then there was the clause "capital allocated to do these areas." The London Company had left this clause out. They did not allocate a single sixpence, and what was the reason of that? Why the reason was too obvious—that they did not mean to do London. They intended to do such bits as would prevent any other company coming in and doing their leavings, or even competing with them in the pieces that they do. They had not omitted the clauses of the model order inadvertently but deliberately, and they knew that those were the most important clauses, and they omitted them because they were fatal to their scheme. As to the two points which had been brought up in support of the abandonment of the model order—the first was that the Board of Trade were themselves committed to the reasonableness of this form of order because the St. Martin's-in-the-Fields order and the St. James's license were similar in form. There could be no argument more fallacious than that. The St. James's license ran about 400 yards each way and was in an exceedingly rich district, and so small that it might be left to the company to lay down mains, and St. Martin's was very much the same thing. Then it was suggested that the local authorities themselves did not wish for it; but local authorities could not be expected to understand these matters—many of them seemed never to have noticed the illusory obligations that the Metropolitan and the London took upon themselves. As to the cry of "No monopoly," there was nothing to justify the Board of Trade in now coming to a different conclusion from what they did in 1883, that potential competition and judicious districting were better for the public than competition within the same area. With regard to breaking up the streets, the thing was exactly the same as it was before, and the Board of Trade was not now willing to allow overhead wires any more than in 1883. The third thing the Board of Trade relied upon so much was the competition of gas. If you took what gas could do in 1882, its competition was now immensely more dangerous when the gas companies had awakened up from their lethargy. Then mineral oil was a much more efficient rival than in 1882. If the rivalry to the electric light was sufficient in 1882 it was more so now. Now what justification was there for thinking that the gigantic system of the London Company would lead to cheaper electric lighting? Their charge of £5 a quarter did not look as if they were going to do any small lighting at all, and there was no evidence that they did not mean to go up to their maximum. If it was considered that about three or four hours represented the bulk of the electric lighting, and that there would be a leak during the whole of the remainder of the 24 hours. When he (the learned counsel) had asked how the many difficulties of the scheme were to be overcome he had always been answered that Mr. Ferranti had got patents. If this scheme broke down it would discredit electric lighting.

Now let him come, the learned counsel continued, to the Electrical Power Storage orders. The two parts applied for were Paddington and the Strand. He could not think that the vestry would continue its opposition to a well-considered scheme. They were willing to allocate the capital, and had undertaken to put down £30,000, and he did not see what more they could desire. With regard to the Strand, St. Martin's-in-the-Fields had no objection to their coming in, and the Metropolitan Company was entirely put out of competition by the fact that it proposed to give a private agreement to the Strand and refused it to St. Martin's. His clients ought to be admitted into the Strand, if only on account of the theatres. He would not occupy the Inspector longer in detail, but the more he looked it at the more he felt that the London Company's order was simply an attempt to hold London.

Mr. C. A. CRIPPS then replied on behalf of the Metropolitan Company. He said that Mr. Moulton had really based his argument on two contentions—first of all, that the matter of districting as against competition was settled once for all by the Board of Trade in 1883. So far from picking and choosing his clients put the whole district on the same footing. They had made arrangements for generating stations for 350,000 lights; they had 700 shareholders; their capital had been subscribed by the public nearly twice over, and they had power to increase it. The Chelsea Company, on the other hand, was in the hands of contractors. In Paddington the competitors of the Metropolitan Company were the E.P.S. Co., but his clients applied for the whole of the district and the E.P.S. Co. for only part, and Mr. Dethridge had expressed a very decided preference for the Metropolitan system. In Marylebone the Metropolitan had the assent of the local authority, and the negotiations had been straightforward. With regard to the South London order, Lambeth was in this position, that they said they preferred the Metropolitan to the London because the Metropolitan applied for the whole district, whereas the London applied for only about a quarter, taking out the best part. But he must admit that there were certain conditions which Lambeth asked which it was very improbable that the Metropolitan Company could comply with; for instance, to come under obligations as regards about 34 miles of streets in a long straggling district. That was an obligation which no company, he thought, would undertake. He believed the Lambeth district went right down to Croydon, and in some parts they would get hardly a penny return. Wandsworth, he gathered, wished them to go there, the local authority making as good terms as it could. In Wandsworth there was no competition; it was really a question between the company and the local authority. He would deal with the Mid-London Order on the following day.

(To be continued.)

SOUTH OF ENGLAND TELEPHONE COMPANY.—At their meeting yesterday, the directors of this company declared a dividend of 6 per cent. per annum on the Preference shares for the half-year ended April 30.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of this Company, held yesterday, after placing £7,000 to renewal fund and £6,400 to debenture redemption fund, and writing off the rebate on issue of debentures - viz., £26,100—it was decided to recommend at the forthcoming meeting of the Company that a dividend of 9s. per share (free of income tax) be paid. This dividend, with the interim one already paid in November last, makes a total distribution for the past year of 5 per cent. per annum, as compared with 4½ per cent. for the year 1887.

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THE INSTITUTION OF ELECTRICAL ENGINEERS.

"Underground Conduits and Electrical Conductors."*

BY JOHN B. VERITY.

(Concluded from page 716.)

There is really sufficient subject matter for a Paper on conduits alone, and in taking up the question of underground conductors I propose to chiefly restrict myself to a consideration of conductors for high-tension electric lighting circuits.

With regard also to underground conductors for low-tension work, I feel that the Edison system, as at present laid down, is thoroughly capable of filling all the requirements of house-to-house distribution. Many companies in the States and elsewhere are using it, and at the down-town station in New York it has been at work for the past six years successfully. In the recent discussion on Prof. Forbes' Paper several points of interest concerning the Edison underground conductors were explained, which it would be unnecessary for me here to repeat. A full description of the latest developments of this system, with samples of the improved form of conductors, &c., are now on the ocean, and in the event of it being possible to provide another evening for a continued discussion of this Paper, I shall be most happy to show and explain them.

Everyone must acknowledge the foresight shown in devising such a complete system of underground mains so long ago, and which, in spite of the all-round developments of electrical engineering, not only holds its own, but is still far ahead in completeness of any system for low-tension underground work. The Westinghouse Company have, I understand, acquired the rights for Great Britain, and presumably will use it in connection with large transformers for sub-centres. It may be also interesting to note that Messrs. Siemens have made *concentric* three-wire cables, which are being successfully used at Elberfeld, Geneva, and Mulhausen, and they state that the troubles from what would appear very complicated jointing have been satisfactorily overcome.

It is underground conductors for high-tension currents that I propose now to deal with. A principal point for consideration is the necessity or not for lead sheathing where conduits or ducts are employed.

As to the durability of lead much absurdity has been talked. It is notorious that lead pipes have been in the ground under all manner of conditions, and at the end of long periods are still intact. There are, no doubt, certain clayey soils where lead has not much lasting power, but the lead may be materially preserved by coating it with coal tar, well tapeing it, and again soaking it in the coal tar or some such protective composition. Again, as Dr. Werner Siemens recently said in reply to Professor Forbes' Paper, owing to the manner in which the lead covering is generally put on to such cables, viz., by heating the lead to the point of melting, and forming it in this condition round the cable, while passing through the press, there is no certainty of a uniform thickness, and it is very difficult to obtain a tube through which damp, in course of time, will not find an entrance, as air-bubbles and impurities in the lead are liable to make the covering porous. A far better result is obtained by covering the insulated cable with a cold-drawn lead tube, as the air which might still be contained in the lead block is compressed to a minimum.

A theory as to partial wasting of lead covering on cables is that it may occur from acid being present in the jute or fibrous insulation, or, again, that the petroleum residuums may set up a chemical action on the lead; but there has not been much evidence on these points. Manufacturers of lead-covered cables have admittedly put on too thin a coating of lead in the earlier days; this has been gradually increased, and with proper conditions and precautions there should not be much fear of its durability.

Iron-armoured lead-covered cables are not necessary if an effective system of conduits is used for mechanical protection. In Berlin, where such cables are employed, they are simply laid in a trench in the ground, and consequently require to be thoroughly protected from mechanical injury. Lead alone is not sufficient.

Dr. Werner Siemens said in his recent Paper, that long years of experience had taught him that although covered with hemp or jute it requires further protection to render it secure against mechanical injury, whether by men or animals, as even rats eat their way through. Such protection is afforded by a double spiral of sheet iron, which again is made secure against oxidation by asphalting or galvanising, or by another cover of tarred hemp or jute. Such armouring as this is quite needless with a well-constructed conduit, but as to whether galvanic action takes place Dr. Siemens has undoubtedly shown by his firm's experience that with a substantial layer of tarred or asphalted jute between the metals it does not occur. This form of armoured cable was laid at Munich for lighting the theatre, and after nearly five years in the ground is as perfect as at first. At other central stations—at Elberfeld, Darmstadt, Geneva, Salzburg, Lyons, The Hague, St. Petersburg—their iron-armoured lead-covered cables prove that constructed in this way there need be no fear of galvanic action at any rate.

Lead sheathing may be made durable, but the actual necessity of it where a conduit is used is quite another matter, and a consideration of the two principal divisions of insulating material has considerable bearing on this point.

Of the fibrous and the homogeneous the latter seems to present some important advantages for insulating high-tension cables. For instance, vulcanised rubber is flexible and tough, and affords a continuous and homogeneous covering which should be superior to a fibrous covering. Vulcanised rubber cables are at times sheathed with lead for mechanical protection, but such is not necessary if laid under good mechanical conditions, and Mr. Lant Carpenter recently said that the sulphur in the vulcanised rubber would attack the lead in the same way it would copper. If, as is stated by many English cable manufacturers, compound vulcanised rubber will well withstand the deteriorating effects of damp and gases, then, the mechanical protection being afforded by a conduit, the necessity of lead as a protector is no longer of importance. It is true unprotected vulcanised rubber cables in conduits have failed in the States, but the competition among Electric Light Companies in America is notorious, and the question as to the maintenance of cables is not considered so much as their relative first cost. The object of the American cable manufacturers, naturally suiting their market, has been to make cables with a cheap form of vulcanised rubber insulation to compete with the jute insulated cables there, and which are cheaper. The vulcanised rubber evidently was not properly prepared, as it should be to permanently counteract the deteriorating effects of damp and gases, by reason of the expense.

All those acquainted with the rudiments of rubber manufacture must be aware of the enormous difference in quality of different vulcanised rubbers. With Para rubber at 3s. per lb., and the desire to sell it at a shilling, all manner of substitutes and compounds have been introduced. While thoroughly appreciating the energy and genius of American electricians, we can confidently say that cables manufactured in this country are greatly superior to those made in the United States; and, as a basis for this belief, we have the fact that most of the cables for high-tension distribution in the States have proved faulty according to their own admittance, while there is undoubted evidence of the successful working of many vulcanised rubber and jute insulated cables in this country and in Europe made by English manufacturers. The statement is made by the Silvertown Company, Messrs. Henley and Co., and others, that they are absolutely prepared to guarantee for a term of years their vulcanised rubber cables unprotected by lead, even if laid in damp and leaky conduits, provided there is suitable mechanical protection against injury and that the cables are laid under competent supervision.

With regard to *fibrous* insulating material, it is alleged that it has the defect of opening cracks when bent. If this be the case, it would became more pronounced when the material is soaked in resinous compound, and perhaps less so when petroleum residuums are used, such as for instance in ozite, kerite, bitite, &c. If cracks are likely to be formed when the cable is bent or twisted about, air paths would be opened up for disruptive discharges.

In the working directions given for the laying of one of the principal lead-covered cables in the States, it says:—"The fibrous material being superdried will readily absorb and retain moisture from the air, and cables showing an insulation resistance of thousands of megohms when first made may after exposure of a small part of the core to moist air for a few hours show a great falling off of insulation resistance." Instructions are therefore given as to carefully sealing the ends of the cable when laying. Again, the 'splicers' hands are cautioned to be kept "perfectly dry and free from perspiration, as a little moisture communicated to the insulation may result in vastly lowering the insulation resistance." These remarks, written by manufacturers of such cables, show the readiness with which such fibrous insulation may deteriorate under conditions likely to occur even if there be the most careful supervision of the men laying the cables. It is acknowledged to be absolutely necessary to cover jute or cotton insulated cables with lead, and it is in this fact that the weakness of such cables seems to lie, as the moisture and gas resisting portion is the lead absolutely, the jute insulation being of little value in this respect. Inasmuch as the majority of underground cables in the States are insulated with such jute or cotton soaked in some compound, it will be at once understood why lead-covered cables are considered in America as the only means for successfully carrying out such underground cable work, especially when the cables are liable to be laid in leaky conduits. It is right to say that apparently few troubles have been experienced in Europe with underground conductors insulated with fibrous material. Messrs. Siemens and Halske, who use a jute covered cable, but manufactured in a different way both as regards the impregnating of the jute and the method of cold-drawn lead sheathing, have a successful record not

* Paper read before the Institution of Electrical Engineers, April 11, 1889.

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only for low-tension cables but for the various concentric cables supplied to Messrs. Ganz and Co., of Buda Pesth, for 2,000-volt alternating currents. They assert that the troubles experienced with American underground cables, whether jute or rubber insulated, are comparatively unknown.

The question between what I broadly term lead sheathed jute or well compounded vulcanised rubber seems to me the momentous one, and as usual each one has certain claims.

It is well known that the cost of jute insulated cables is less than that of high-class vulcanised rubber insulation, but this would have little weight unless they can be proved in every respect equal to vulcanised rubber. In a comparison of the different costs of such insulation vulcanised rubber appears to be about 25 per cent. more for approximately the same insulation resistance. In making this comparison I took the cost of a vulcanised rubber cable, insulated with one layer of so-called pure and two coatings of vulcanised rubber, taped, braided and coated with preservative compound but not covered with lead, as this is a superfluity, the cable being watertight without this addition. The jute insulated cable I took as cased with lead and protected again by a covering of tarred jute yarn compounded.

After the relative cost comes the question of jointing, and as this is one of the most vulnerable points in any cable it is of vital importance that the joints should be made as good as any other part. With vulcanised rubber cables the joints must be vulcanised, and first-class rubber men who would make such joints speedily should be on the working staff. With lead-covered cables a plumber would have to be employed, and I am informed by those who have had experience with both forms of cables that the vulcanising is preferable to the plumbing.

Vulcanised rubber cables are certainly easier to handle, being more flexible, ductile, and lighter, and this is of importance in view of the difficulties occurring in drawing cables in and out of a conduit.

Again, when lead-covered cables are coiled round a drum the part nearest the centre becomes compressed, while the outer portion is extended; on uncoiling the cable the opposite effect is produced, the parts before compressed being now pulled out and the extended portion compressed. This is trying to an inelastic substance like lead, the more so when, unlike an empty lead pipe for water, it is filled with an insulated cable. It is quite conceivable that the surface of the lead may be slightly broken up, particularly when the method employed is to cover the lead hot round the cable; and although no cracks may be visible to the eye, gas and moisture might be apt to find their way in very quickly, with corresponding deterioration of the insulation.

Next, as to whether jute or vulcanised rubber is better suited for insulating high-tension alternating cables no opinion can yet be given. It is well known that on submarine cables working with reversed currents it is usual at times to give the cable a rest. This necessity may be due to the action of the reversed current on the insulation, and it would be interesting to know how the much more powerful currents and rapid reversals of an electric light circuit will affect the insulation of a cable after carrying such currents for a considerable period. In some interesting Papers, published last year by Mr. Addenbrooke, he came to the conclusion that a high-tension alternating current should have less effect on any dielectric than a continuous current of the same potential. He argued that owing to the rapid alternations there would not be sufficient time to fully charge the dialectric, as before this could occur the next charge would sweep out the former charge, partially recharging it in the opposite direction. But it would certainly appear that such an action as this on a dielectric would be far more injurious than for it to be fully charged as with a continuous current.

From a careful review of what I have seen in the States and elsewhere I must confess that my own feeling is in favour of a cable insulated with thoroughly good vulcanised rubber for high-tension work, and I was interested to hear Sir William Thomson say on Monday at the Board of Trade Inquiry that if high-tension conductors were protected in an iron pipe a lead sheathing to them was not essential.

Those acquainted with the present manufacture of rubber cables know that pure rubber proper is not used for their insulation. However good the rubber may be there is always a certain amount of impurity and oils which will set up decomposition sooner or later. This is overcome by slightly vulcanising the rubber, but so that there shall be no surplus sulphur to attack the copper. In the high-class cables now made by the Silvertown Company and others the practice is to put next the conductor after cotton twist a substantial coating of pure India-rubber, slightly vulcanised, upon this a coating of zinc rubber with vulcanising materials, and covering this a compound vulcanised rubber of great resisting qualities to damp and gases. The zinc rubber takes up the surplus vulcanising material of its two outer coverings, so that the copper cable is not injured by the sulphur used in the process. Such an insulation as this is as good as could possibly be desired for any high-tension currents, and is absolutely perfect so long as the covering is continuous; and as the whole of the materials are treated at a temperature of 400 deg., any rise in temperature of the conductor due to accidental overloading will not injure the insulation. With regard to the outer protection of the compound vulcanised rubber, there may be still scope for further improvement, as, for instance, in the cables recently made by the Silvertown Company for the London Electric Supply Corporation two braidings of asphalted tape have been used, and this is found to be satisfactory. Among the instances where vulcanised rubber cables have stood stringent tests has been at Eastbourne, where Mr. Lowrie has used Silvertown cables laid in iron pipes for two years, and states they are still in perfect working order. He has also put down there a length of Fowler's Tatham lead-covered cable for continuous current high-tension work, the fibrous insulation being well wrapped round several times with tape. This has also been working successfully, and in the House-to-House Company's station he proposes to try each method of insulation on different circuits, although the advantages of handling the India-rubber cables are in their favour.

The Silvertown Company have five miles of vulcanised India-rubber insulated cable sheathed with iron wires at Brussels, with 1,400 volts constant current. This was laid in the sewers two years ago and is now quite satisfactory.

This company have also supplied two miles of such cable, but with asphalted tape on the outside, to the London Electric Supply Corporation, with 2,400 volts alternating current, the conductors being laid in an iron pipe.

There are also samples on the table of a piece of Messrs. Henley's vulcanised rubber cable that has been in use overhead for ten years.

A difficulty with underground conductors in the States seems to be disruptive discharges, and I trust the discussion may bring forth information on this subject. Owing to the frequent puncturing of the insulation, attended with pin-holes in the lead covering, Mr. Acheson, the Waring Company's able electrician, and whom I desire heartily to thank, turned his attention to the matter, as the pin-holes by admitting moisture defeated the object of the lead sheathing and proved fatal to the life of the cable.

Mr. Acheson's theory is that the static electricity generated in the cable after a time punctures the dielectric by discharging itself between the copper conductor and the lead sheathing, and the protector shown in Fig. 12 is designed to obviate this.

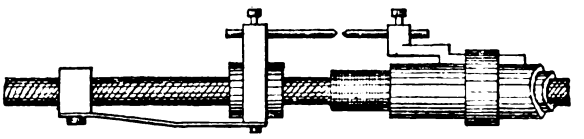

Fig. 12.—Mr. Acheson's Cable Protector.

This consists of two metallic points separated by a distance which is less than the thickness of the cable insulation; the one point is connected to the lead sheathing, and the other through a fuse wire to the copper conductor, the idea being that the static discharge would take the shorter path between the points instead of rupturing the insulation. Mr. Acheson says these dischargers should be placed at every section of a cable, and if the sections are more than 200ft. long there should be one at each end.

To show the exceedingly minute path necessary for a discharge it may not be out of place to quote Mr. Acheson's experiment. A plate of glass about one-tenth of an inch thick was broken in two pieces, and the two parts immediately fitted to their former position and clamped. The restored plate was placed between two discharging points, and so long as the points were over the solid glass no discharge was obtained, but upon removing it so that the line joining the points would lie in the plane of the fracture a discharge immediately occurred.

A possible cause of a disruptive discharge might be that on high-tension circuits of great self-induction—as, for instance, on arc-lighting circuits, where lamp coils form part of the line—the induced current on breaking the circuit is very violent, and in preference to discharging through the line, and consequently the lamp coils, it gets away by rupturing the weak insulation and passing through to the outer earthed casing.

The exemption from such trouble is credited by many entirely to a thicker insulation being used, and in calculating the insulation for a high-tension cable it should be made sufficient to withstand a disruptive discharge of this nature and tested accordingly. For instance, owing to the almost daily occurrence of burn-outs with some cables in Chicago with $\frac{3}{32}$ insulation, laid in November, 1887, the four miles laid in December, 1887, had $\frac{4}{32}$ insulation, and the two miles laid early in March, 1888, have $\frac{5}{32}$ insulation. Careful experimental work is essential before the sufficiency of insulation for such underground cables can be accurately determined, and our leading cable manufacturers naturally keep the results of such experiments to themselves.

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Concentric cables, although so extensively used by Messrs. Ganz, of Buda-Pesth, in their stations, do not appear as yet to have met with favour in the States. It is, of course, undesirable to use ordinary lead-covered cables for alternating currents, both on account of the loss from induced currents in the lead sheathing and the annoyance to workmen handling them. If, for instance, while handling a conductor conveying such a current the lead covering be insulated to any extent on each side of them, the workmen would receive the induced currents through their bodies. Again, when the two legs of an alternating current are in separate cables, and the cables laid in insulating materials, any chance contact or connection between the leads might cause the induced currents to pass backwards and forwards at these points, thus tending to cut away the lead covering as the result of any sparking at poor contacts between the two leads. The Waring anti-induction cable, with both wires enclosed in one sheathing, is well known, and in this the currents induced by both wires being equal in power and opposite in direction tend to neutralise one another.

Mr. Ferranti, by employing concentric cables for conveying the high-tension currents from Deptford station, has brought such cables into prominent notice in England. A concentric cable is obviously the best on theoretical grounds for the elimination of induced currents, as their reaction upon one another is necessarily strongest in the axis of the current. The question as to the necessity of insulating the outer conductor of concentric cables has recently had considerable attention given to it by Mr. Preece, on behalf of the Post Office authorities, and as a result of his experiments they evidently must be so insulated. All the concentric cables made for Messrs. Siemens and Halske for Messrs. Ganz and Co. are of the usual stranded wire form, and the outside conductor, after being well insulated with jute, is covered with a cold drawn lead tube, having an outer iron armouring as previously described. These cables have been successfully used in Rome, Tivoli, Turin, and Milan, in each case carrying a potential of 2,000 volts.

The difficulty of making satisfactory joints with concentric cables must be to a certain extent against them, as it is impossible to see what has been done inside. Messrs. Siemens say that it can be readily accomplished. The Silvertown Company have made several forms of concentric cables, highly insulated with vulcanised rubber, with considerable success for ship work, and they also have an arrangement for constructing the joints.

As to whether concentric cables will be largely used in this country much depends upon the system of distribution employed. For long lengths of cable used as feeders to sub-centres, or to systems of distributing mains, they would be of considerable advantage, as no joints would be required *en route*, but in house-to-house distribution with frequent joints a pair of separate cables near to each other would appear the more easy to handle and the more practicable to operate. In summing up this matter it would appear that the relative advantages are as follows:—1st. The greater convenience of making joints on separate leads as against the trouble involved with concentric cables. 2nd. As regards the relative cost between two separate cables and concentric cables with the same insulation resistance, vulcanised rubber unsheathed concentric cables with outside insulation are dearer, but with jute insulation for concentric cables and lead sheathing they are cheaper. 3rd. There remains the increased efficiency on an extensive system of alternating currents by the use of the concentric form.

With regard to the second point, the figures showing these are:—

For vulcanised rubber, two Silvertown $\frac{1}{12}$ conductors insulated to 5,000 megohms at 60 deg. Fahr., taped and braided over all, specially prepared for underground work, £255 per mile each = £510.

A concentric conductor of equivalent capacity, the internal conductor insulated to 5,000 megohms, as above, but the outer to 3,000 only = £900, being a difference against the concentric conductor of £390 per mile.

If the outer insulation is reduced to 1,500 megohms the price falls to £630 per mile, which is £120 above the cost of separate leads.

On the other hand, for Messrs. Siemens' specially prepared jute insulation two single conductors of the same insulation at £220 per mile each = £440.

A concentric conductor of equivalent capacity, the outside insulated to 900 megohms, lead sheathed, taped and asphalted, £363 per mile.

All cables for high-tension currents should be well tested before leaving the factory. In other branches of engineering the engineer would not think of receiving his steam or hydraulic pipes without first seeing them tested to, say, over twice their working pressure; it is not sufficient for him to see simply that they will hold water or steam, but he must satisfy himself that they are strong enough for the pressure they have to carry. In the same way the electrical conductors which have to transmit energy, much as the steam and hydraulic pipes do, should be tested to twice their working pressure. With the outside well earthed, the current should be allowed to traverse the conductor a considerable time, and an electrical test taken afterwards for insulation. With electrical cables for underground work passed in this way, and satisfactory in other respects, there should be no fear of break-downs under ordinary conditions.

In dealing with a subject of such wide extent and great importance as this it is impossible to do justice to all the workers in the field. I have left out much that may be considered interesting and important, but the difficulty has been, with the mass of information on the subject, what to put in and what to leave out. Doubtless there are many instances of cables and conduits having been successfully at work which have not been mentioned in this Paper, and I hope such information will be forthcoming. If the discussion following be the means of clearing up some of the doubtful points surrounding the subject of underground electrical work, and of demonstrating the direction in which successful work should be undertaken, the object of this Paper will be fully accomplished.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *April* 20, 1889.

One of the most interesting studies in American social and political life is to watch the manner in which the various bodies and authorities of the nation and the States exercise their different functions, which at the first glance to anyone unacquainted with the country would seem to be hopelessly contradictory and conflicting. The average visitor from abroad comes here impressed mainly with the idea that the United States constitute a great Republic, and very often he goes away after a short sojourn without realising that after all each State is an *imperium in imperio*. The fact is, that although the States have delegated large powers to Congress and to national officials, they still reserve to themselves individual legislation on most conditions which affect, directly and indirectly, the welfare of the citizen; and hence a large number of cases which in England, for example, are carried up from, say, Cornwall or Northumberland to the Imperial Parliament at Westminster, are disposed of at some such small State capital as Augusta, Maine, or Columbia, South Carolina. Now and then, however, the case presents itself as to whether bodies holding powers and franchises from Congress are not enabled thereby to free themselves from conditions imposed locally in the different States, and just such an issue has now been raised by the Western Union Company in this city in its endeavour to escape from the provisions under which the New York Board of Electrical Control lives, moves, and draws its salary. Telegraph companies that have accepted the restrictions and obligations of laws passed by Congress have thus become business agencies of the Government, and are given the privilege to construct, maintain, and operate lines of telegraph "over and along" any post road of the United States, provided they do not interfere with ordinary travel. It has been decided that wherever a postman goes is a post road, and as every street in New York is visited by postmen it follows that they are all post roads, to which the Western Union Company, having accepted the national terms, has right of access. The same statement of affairs applies to railroads, all of which carry the mails, and are therefore post roads along which telegraph wires may be strung. In fighting the Board of Electrical Control, and invoking the aid of the national court, as it did last week, by asking Judge Wallace, of the United States Circuit Court in this city, to give it an injunction against the board, the Western Union Company took the ground that the State authorities or laws were invading the national jurisdiction, and that there was no defence for the board's conduct in trying to drive the telegraph wires underground. Judge Wallace held, however, that the statutes which the board were endeavouring to enforce unquestionably belong to the category of police regulations, the power to establish which had been left to the individual States, and it was not apparent how the method proposed by the board impaired in any just sense the privilege granted to the Telegraph Company by the law of Congress. The privilege to maintain telegraph wires "over and along" post roads was not to be construed so literally as to exclude regulations by the State respecting location and modes of construction and maintenance demanded by the public interest and sentiment in each locality. In this view of the case Judge Wallace directed that an order be entered

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denying the injunction asked for by the Western Union, thus leaving its poles and wires subject to the tender mercies of the board. With regard, however, to the wires and cables of the company placed along and under the elevated railroad structure, the Judge held that they were not in anybody's way and were not objectionable, and must therefore not be interfered with. This little concession was something perhaps; but the defeat on the main issue may be serious to the Western Union Company, as it has a great many miles of wire throughout this city on pole lines and housetops; and as the board "means business" there seems nothing now to prevent those poles and wires from being chopped down, a performance which we are promised this week.

It is a trifle unfortunate for the Western Union Company, if it is in earnest, that some of its own experts recently should have filed affidavits with the board as to the successful operation of underground electrical systems, and that the company cannot very well fall back upon the results of its underground work in other cities. I believe that in Boston and Chicago, as well as in this city, it has obtained very fair results from its underground wires and cables, and so far as this city is concerned it would have done much better but for the fact that the Steam Heating Company down town persisted in turning the Western Union subway into a witches' cauldron, in which the cables were stewed and boiled, like so many eels, and until there was no virtue left in them. That the Board of Electrical Control is determined to have its authority respected in this matter may be inferred from the fact that it has already used its axe to some purpose up town. Last Saturday it made a raid on the wires of the West Side Electric Light Company, which put in a Fort Wayne Jenney plant, and having failed to obtain a franchise from the board, settled down cheerily to business without one. It ran its circuits in every direction wherever a customer offered, and "by strict attention to business" was really getting along very nicely, and turning more than one honest penny; but all of a sudden the myrmidons of the board swooped down on it, and before the company knew what had happened about 10,000 feet of its wire had been carried off and dumped in the Corporation yard. I am sorry for the company, and it would be interesting to know just why it could not obtain a franchise; but, of course, to engage in business in this extensive manner without any official warrant was very much like flying in the face of Providence, and it was utterly impossible that the board should long tolerate this defiance of its authority.

I might add that since I wrote the earlier part of my letter the cutting campaign has actually begun, and a large number of poles and wires have been cut down within a small district extending, roughly, from Fourteenth-street to Twenty-third-street and Broadway and Sixth-avenue. The work has been witnessed by large crowds of people, and has been attended with exciting incidents, including the fall of one rotten pole on a street car, whose inmates it greatly frightened, the laming of one young lady, who stubbed her toe against the bolt of one of the posts, and the killing of a lineman jerked from a window, his companion being also seriously hurt. As the result of this work other districts besides those over which the wires run have suffered the loss of their electric lights, and the gloom of the streets at night, even where the restored gas lights have been in full blaze, has been most dismal and depressing. People are beginning to realise very clearly what a blessing the electric light is, and all the newspapers comment on the dreary effect which the extinction of the arcs has had.

The controversy over the storage battery patents has been carried forward another stage by the action of the Electrical Accumulator Company, which has filed a disclaimer in the way suggested by Judge Coxe, and has limited its patents to storage batteries made by the application of the active material in the form of paste, paint, or cement. This disclaimer has been approved by the Court, and an injunction issued restraining the Julien Company, the Fourth Avenue Railroad Company, and any others, from the use of batteries of that type. The Julien cars are still running, however, on Fourth-avenue, as the company state that they do not make their batteries in that way, their active material being applied, it is alleged, in the form of a powder. During the present week we have been honoured with a visit from the Boston Board of Aldermen, investigating the rapid transit problem. The Board were given a run, which they enjoyed very much, on a Julien car, and some of them think that storage battery cars would be a good thing in Boston. The Julien Company have published a statement this week giving the figures of the operation of their last car, No. 7, put in operation on the Fourth-avenue road, making 57 miles daily in five round trips. The earnings during the past 40 days of this car have been $998. 10c., exclusive of 998 transfers, for which it gets no credit. This is at the rate of $9,106. 75c. per annum, while the average earnings of horse cars on the same line are only $6,387. 50c. Deducting from this $4 a day for driver and conductor, $3. 60c. per day for motive power, wear and tear, and royalty, and 6 per cent. interest on $6,000, which is the cost of the car, with battery racks, stationary motors, switches, &c., the net earnings for the year of the storage car are $5,972. 75c. During the forty days that the car has been in operation up to date neither the batteries nor the motors have required attention or the expenditure of a dollar for renewals or repairs; and it is stated also that on car No. 1, which went into service on the 1st of September last, the batteries, when examined for the first time on April 8, were found to be in as good condition as when put in service, although they had not been lifted from the cells in the whole period to be cleaned or inspected. It will be admitted that these are remarkable statements, but as the company is ready to take all the business that comes to it under penal guarantees, it will be seen that they have the courage of their figures and convictions.

VIENNA NOTES.

(FROM OUR OWN CORRESPONDENT.)

VIENNA, *April* 30, 1889.

The Vienna Telephone Company have just held their annual meeting. The position of the company is a good one. After declaring a dividend at the rate of 8 per cent., the shareholders decided on increasing the company's capital from 800,000fl. to 3,000,000fl. The number of subscribers is increasing so rapidly that a new exchange is being built to accommodate 3,000 more. At present 2,000 subscribers are connected. This will enable the company to connect up to 5,000. The subscription is now 100fl.; a year ago, when it amounted to 150fl., the number of subscribers was only 800. Nearly all the lines in Vienna are underground, and new cables to accommodate 1,000 subscribers are to be laid this year. The new exchange will be fitted up with an improved multiple board to be made by Mr. Otto Schaffler.

The new central electric light station of Messrs. Siemens and Halske is being pushed forward vigorously, and the chimney is nearly finished. They hope to begin working in the autumn.

Mr. Werndl, the general manager and principal owner of the great small-arms factory in Steyr, died suddenly on April 28. Mr. Werndl was a remarkable man; the great factory in Steyr was his own creation, and has put out since 1867 more than 2,100,000 rifles, and is now working on supplying the Austrian and German Governments with their new repeating rifles, turning out over 10,000 a week in Steyr and Vienna. Mr. Werndl began as a small gunsmith. During the years 1882 to 1886, when the factory had little to do, he busied himself with electrical experiments, and was the first in Austria to make use of the electric light on an *extended* scale. He also made many experiments in using water-power to drive his dynamos, and succeeded so well that many followed his example. It was also entirely due to him that the late Electrical Exhibition was held in Steyr.

CORRESPONDENCE.

DR. LODGE'S EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some of those who were present at the reading of Dr. Lodge's Paper before the Institute of Electrical Engineers were interested to notice a curious incidental phenomenon which occurred in the course of the experiments. The miniature rain-storm was in full swing, the two zinc tanks being connected with the Wimshurst machine by wires perhaps four metres long. The phenomenon appeared on one of these wires. Whenever a spark was produced in the circuit a faint luminosity, about the size of an egg, appeared to run along this

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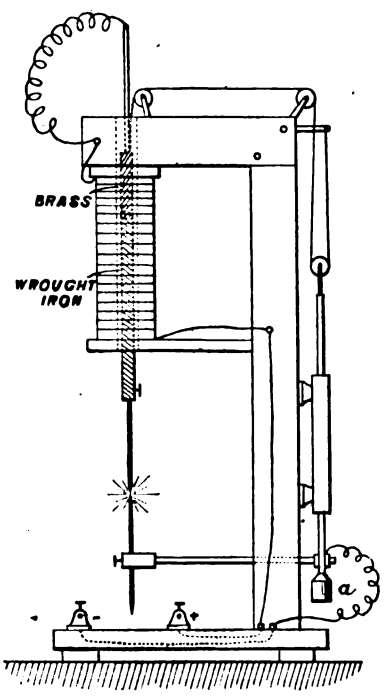
wire from one end to the other, occupying perhaps a second in doing so. "That," said Dr. Lodge, "is a brush." No doubt his explanation was correct as far as it went, but he did not explain why the brush seemed to *run along the wire*. I had always thought that an electric current, so far from "flowing," occurred almost simultaneously at all parts of a circuit, or at any rate flowed at such a pace that if it were visible its motion could not be followed by the eye. But here was a brush, resembling nothing so much as a luminous mouse, which was distinctly seen to travel along the wire, occupying an appreciable time in transit. Why did it not "occur" simultaneously at all parts of the wire? Is this another case of the persistence of an image on the retina? I shall be grateful if someone will enlighten the darkness of IGNORAMUS.

ARC LAMPS FOR AMATEURS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I designed some years ago a small arc lamp easily made up by amateurs. The regulating mechanism is the same as that described in your last issue, p. 689, but I think it capable of giving a steadier light, and it can be used for light-projecting by means of a reflector. This lamp is principally convenient for amateurs because it is nearly all made of wood. The box *a* is to hold small shot necessary to adjust the lamp



according to the current supplied.—Yours, &c.,

R. P. BOUQUET, Ingénieur des Arts et Manufactures.

Havre, 9, Rue Caligny.

LAHMEYER'S SYSTEM OF REGULATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your note on the Müller and Lahmeyer system of distribution, it is interesting to note that this is an extension of Prof. Perry's method of maintaining constant potential at the end of a circuit, which was patented about 1882.

The advantage of the differential winding over plain series is questionable, for though it doubles the range of E.M.F. it involves variable lead of the brushes, and, like all differential winding, is expensive in copper.

The use of compensating series dynamos was proposed for the Birmingham electric lighting scheme, and was included in a provisional specification dated June, 1888.

Although the method at first sight looks very promising, it seems questionable whether it has any advantages over compound or regulated shunt dynamo when the feeders are supplying a continuous network of distributors.

In cases where several isolated centres are supplied from a single station the system would be very useful, but such cases are not likely to occur in low-tension distribution.

The disadvantage of so many extra machines is obvious.—Yours, &c., R. H. HOUSMAN.

Birmingham, April 30, 1889.

THE INJUNCTION AGAINST THE JULIEN COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg to hand you copy of injunction order issued under the recent decision of Judge Coxe in the United States Circuit Court for the Southern District of New York, in the case of the Electrical Accumulator Company against the Julien Electric Company, which has been forwarded to us by the solicitors of the Electrical Accumulator Company of New York.—Yours, &c., H. DELL,

Secretary Electrical Power Storage Company (Limited).

London, May 1, 1889.

[Our readers will scarcely be interested in the legal formularies of the United States Courts, but the following is the claim upon which the injunction is based:—"Any polarisation or secondary batteries containing or embodying an electrode consisting of a support coated on one or more faces, with an active layer of absorptive substance, such as metal or metallic compound, applied thereto in the form of a paint, paste, or cement, and practically insoluble in the electrolytic liquid, so as to be or instantly become spongy, and thus capable of receiving or discharging electricity." Some further information will be found in our New York letter in the present issue.—ED. *E.*]

COMPANIES' MEETINGS & REPORTS.

The Indo-European Telegraph Company (Limited).

The twenty-second ordinary general meeting of the members of this Company was held at Winchester House, Old Broad-street, on Monday, Mr. J. Herbert Tritton, the Chairman of the Company, presiding.

Mr. W. ANDREWS, the Managing Director, read the notice convening the meeting, and the seal having been affixed to the register of shareholders, the report and accounts were taken as read.

The CHAIRMAN said: I have now to move the ordinary resolution:

"*That the report and accounts now submitted be received and adopted, and that a dividend be and is hereby declared for the half-year ended 31st December, 1888, of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, together with a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year.*"

Mr. H. WEAVER seconded the resolution.

The CHAIRMAN: Before I put the resolution perhaps you would allow me to make one or two remarks upon the course of business during the year 1888. You will have observed that the receipts amount to £110,327 which is an increase of £6,036 beyond the gross receipts for 1887. The expenses amount to £52,393, as compared with £48,620, which shows a gross increase of expenditure of £3,772. On the commercial account, under the head of salaries, we have paid away £500 more in wages. That is mainly due, I believe, to the fact that this Company transacted for a month the whole of the Indian business. During the year 1888 there is also an increase of something like £250, which has been caused by two years' rent paid for the Warsaw station in one year. There are one or two other minor increases; but the chief increase is £955 in agency expenses, which arises from the fact that these expenses, which formerly were partly borne by the Gulf Department of the Indian Government, are now altogether borne in this country by this Company. There is one item in the expenditure which I think will, without doubt, meet with your approval, and that is a donation of 200 guineas, which the Board felt themselves free to make to the German Inundation Fund under the distressing circumstances of the time. Turning to the maintenance department, there is an additional outlay, consequent upon a reorganisation of the staff, of £1,608, which results in a lessened expenditure in the future. This will not recur. Turning to the traffic, I have to observe that it is from some points of view slightly discouraging, although, as you will observe, there is, on the whole, an increase. The one discouraging feature is, in fact, that the Indian traffic pure and simple does not bring us in now what we might reasonably have expected it would bring us in. The rate for Indian messages was lowered in the year 1886, and we have not benefitted; on the contrary, we have suffered from that lowering of the rate. The messages have not been increased as some expected they might have been increased. The increase to which I have referred, therefore, has been made up out of other than purely Indian messages—that is to say, trans-Indian, Australasian, Persian, and South Russian messages. It may be interesting to you also to know—which is again a somewhat discouraging fact—that the number of words per message is steadily decreasing. In the year 1880 the number of words per message was 18·83; it has gradually and steadily declined until in 1888 the number of words

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per message was only 12·66. This must be attributed, we suppose, to the greater perfection in what is called "coding," whereby very much more is conveyed than the number of words employed. As respects the Indian messages, I have already mentioned that there is actually a falling off. This falling off is not only in the number of messages, but also in the number of words. This falling off in the number of words does not apply to our trans-Indian business. A review of all the circumstances drives us to the conclusion that it is not so much the tariff which regulates the traffic as the activity or sluggishness of trade or commerce. At these great distances, where the cost of telegraphic messages must be appreciable, owing to the enormous mileage traversed and the necessarily great outlay upon special lines of communication, which have to be maintained in the most perfect order, the tariff can never be so low as upon lines where messages travel longer and shorter distances indifferently, so that there may be a mean distance which may be comparatively short when all the traffic is taken into consideration. For instance, the minimum distance from this country to India is 5,848 miles to Kurrachee; but this distance is largely increased on the average because the bulk of the traffic is exchanged with Calcutta, 7,624 miles; or Bombay, 6,617 miles; or Madras, 7,337 miles; or Rangoon, 8,600 miles; or with the Presidency towns. Then, in the case of Australia, there is a minimum distance of 11,804 miles; but this distance is often very largely increased. For instance, Melbourne is 14,349 miles distant, and so on; so that looking at the large portion of the globe traversed by Indian and trans-Indian messages, it is certainly a cause for astonishment and congratulation to see to what marvellous perfection the Indian Government and Indo-European Company have brought the service, and the perfect state of communication with India by telegraph. Next year there will be a telegraph conference held in Paris, to which we look forward with feelings not altogether unmixed with anxiety. We never know quite what may be said or what may be done at these telegraph conferences, and we have, as you are aware, large interests to foster and protect. In the past the reductions which have been made at these conferences have not proved very fruitful, unfortunately; for the European telegraphs as a whole are worked at a loss. They are mostly in the hands of Governments as we know. I believe I am right in saying that our own British telegraph service is worked at a loss, and the question arises how far the senders of messages, who send them because they expect to make a profit out of the business they are conducting, are to be practically subsidised at the cost of the general community. It seems to me that this is a question which ought to receive the serious attention of the proper authorities. The telegraph, in fact, ought to pay for itself and return a fair interest upon the capital and labour employed, just the same as any other business, whether its proprietors are States or private individuals like ourselves. In conclusion, gentlemen, I can only express the satisfaction which you and we may feel at the very satisfactory manner in which the business has been done during the past year. That has been largely owing to the exertions and efficiency of the staff, which is second to none in the telegraph service. That staff has been watched over and looked after by our good friend, the managing director, Mr. Andrews, who devotes a very large amount of energy and business ability to the conduct of our affairs. We owe to him, as well as to the staff, a great deal of thanks. There is one other matter to which I must also allude before I sit down. You will have observed the report states that Colonel Holland was compelled to resign his seat at the Board. That he did, to the great regret of his colleagues; but since then he has died. His colleagues regret his death exceedingly, and you, gentlemen, I am sure will also regret it extremely. Most unexpectedly he has passed away from us, and it will be your wish I am sure that we should express to his family through his son, who is not able to be with us to-day, the sincere sympathy which we all feel with the family at the loss which they have endured. Colonel Holland was Chairman of this Company for nearly twenty years; we could not have had a better Chairman, or one more conversant with its affairs or more experienced in Indian business. We shall feel his loss very much indeed. Gentlemen, I beg to move the resolution which I have already read to you. That resolution has been seconded by Mr. Weaver; but before I put it, if there is any gentleman who wishes to make any observations or ask any questions, I shall be happy to hear them.

Mr. JACKSON: Mr. Chairman, may I be allowed to intrude for a few minutes to ask a question with reference to the possible future of this Company—I mean in view of the expiry of its concession. I think we all ought to feel, as I have no doubt we do all feel, that the admirable management in the past and the sound judgment of the Board has secured for us a very satisfactory return; but I think, sir, it must be patent to everybody that the assumption by Government of the telegraphic service as part of the postal service of every country is but a question of time, probably only of a short time. I would very respectfully, on your accession to office, ask your serious attention to that point. While I feel the validity of your remarks with reference to our late Chairman, I also feel that we have reason to congratulate ourselves on having a gentleman of your position and financial ability to take his place. But I think the matter I have referred to is one we may in all respect ask the Board to take into their consideration in view of the future. We have seen in reference to our neighbour, the Submarine, that there has not been that consideration or solicitude for the interests of shareholders exhibited by the Governments concerned that we might naturally desire or expect for the pioneers who have undergone—perhaps not so much in their case as in our own—all the brunt and the heat and burden of the day. Still, I think forewarned is forearmed, and I think the Directors might very fairly consider the advisability of returning, in whatever form they see to be possible, a portion of the capital to the shareholders, so that when the time does come we shall not, at all events, be caught in the toils of diplomacy and have to suffer in our pockets by the resumption of this concession by a Government concern. I see that we have something like 25 per cent. of our capital in the reserve fund. Of course, that is necessary for the backbone of the Company in order that you may be able to meet every possible casualty or contingency; but, at the same time, many of us shareholders would like to see some portion of the money "in fisto." In what way that can be done must, of course, depend on the judgment and care of the Board; but still, it is a matter which we ought, I think, to deal with. I took the liberty of writing to your predecessor, Col. Holland, but his health was infirm, and he was unable to give the matter attention. I have nothing further to say, except to express the satisfaction of myself—and, I think, of every shareholder—at the excellent results shown. I should like to say just a word with reference to the Indian traffic. Of course, as you have pointed out, it depends more on commercial activity and prosperity than on the reduction of the traffic; but it is an abnormal thing that a reduction of tariff should not lead to increased trade. Of course, ultimately we may hope for that. However, I should consider that you might freely dispose of a portion of the reserve fund, because with a smaller amount of capital the same dividend might be paid, and in such a way we might safeguard the interests of the Company. I am much obliged to you for your attention to my remarks.

The CHAIRMAN: No other gentleman rising to put any questions, I will reply to Mr. Jackson. I think Mr. Jackson was one of the earliest shareholders in the Company, and he will remember that there was in the old Articles of Association a clause whereby we were obliged to establish a sinking fund; but under the force of circumstances to which he alluded when he mentioned the pioneers who have had to bear the heat and burdens of the day, it was impossible to carry out that arrangement during the first few years. When we made no money and paid no dividends it was impossible for us to start a sinking fund, but latterly we have been in circumstances which have enabled us to put by money until now we have something over 25 per cent. of our capital in reserve. That we must look upon partly as a fund against contingencies and partly in the light of a sinking fund. Our concessions come to an end in something less than 20 years. There is a clause both in the Russian and in the Persian Concession under which the Company is bound to come to terms with those Governments, and we hope and believe that that implies that the Governments will conceive themselves reasonably bound, in considering those terms, not to enter upon a course of confiscation. We do not for a moment suppose they would think of anything of the sort; but on our part we must also be reasonable if we expect them to be reasonable, and no doubt we shall find both parties to the Concession reasonable when the time arrives. The point has been constantly before the Directors. It receives and shall continue to receive our best attention; but whether or no it is possible to follow out Mr. Jackson's implied desire that we should actually divide up our reserve fund I cannot now say. My own feeling, both in this and other places, is that a body of shareholders is well advised in seeing that the directors so conduct their business that they are enabled to have a very substantial amount in reserve against contingencies of all sorts and kinds. That would be my own feeling very strongly both here and elsewhere. Gentlemen, I thank you for the patience with which you have listened to me, and for the way in which you have received the motion, which I now beg to put.

The motion was then put and carried unanimously.

The CHAIRMAN: I have now to state that in accordance with the Articles of Association the following Directors retire by rotation:—Mr. C. W. Earle and Mr. J. Von Berenberg Gossler. Both these gentlemen are eligible for re-election and offer themselves accordingly. If it be your pleasure I will put the resolution that these two gentlemen be and are hereby reelected Directors of the Company.

Major-General G. B. TREMENHEERE, R.E., seconded the resolution, which was carried.

Mr. WOODMAN next moved—

"*That Messrs. C. F. Kemp, Ford and Co. be re-elected auditors for the current year.*"

Mr. SMITH seconded the motion, which was adopted.

The CHAIRMAN: That, gentlemen, concludes our business, and I have only now to thank you for your attendance.

Mr. JACKSON: Gentlemen, I do not think we can leave this, the first meeting at which we have the pleasure of welcoming our new Chairman, without passing a vote of thanks to him and the Board, and I beg to propose—

"*That the best thanks of the shareholders be accorded to our Chairman and Directors for the conduct of our affairs during the past year.*"

Will some gentleman kindly second that?

The motion was seconded by Mr. WOODMAN, and adopted.

The CHAIRMAN: Gentlemen, I thank you for this renewed vote of confidence and thanks on your part. We shall continue to do our best to merit it.

The meeting then closed.

The Great Northern Telegraph Company of Copenhagen.

The following is an abridged report of the general meeting held at Copenhagen on April 27 last, under the presidency of Mr. F. Zahle. The report of the Directors was summarised in our issue of April 26.

The chairman of the Company, Mr. C. F. TIETGEN, in rendering an account of the working of the Company during the year of 1883, first referred to the state of the Company's cables, which had not been quite so satisfactory as in the previous year, as the interruptions had been more frequent. In Europe thirteen interruptions and in the Far East eight had occurred, without, however, affecting the receipts in any sensible degree. The Company's cable steamer in Europe, the "H. C. Orsted," had been employed for 143 days, including eight days in the laying of a cable in the

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Baltic, between Gjedser in Denmark and Warnemünde in Germany, for the joint account of the Danish and German Governments. The repairing steamer in the far east, the "Store Nordiske," had been at work for 146 days, out of which 50 days had been for foreign account.

The Traffic Revenue had exceeded that of the year of 1887 by about £8,000. From this fact the shareholders would no doubt have drawn the inference that the losses anticipated as consequential upon the Chefoo Convention—a subject which was largely referred to in the last report—had not yet been felt. And so it was; because the Convention had not yet been ratified by the supreme authorities in Peking.

The Company's position in China.—It would have carried him too far here to enter into details of all the complicated phases through which this question had passed, a description of which might only prove misleading to the uninitiated. The fact was, however, that the Company had as nearly as possible come back to the point of departure of the previous year, viz.:—That all the parties interested sincerely desired a final solution; and since then it would appear that it had been more a question of form than of any substantial divergencies which had stopped the way of the ratification. With a little goodwill on all sides—and the Company had certainly shown much of this—the affair could no doubt at any time be settled very expeditiously.

Financial Considerations.—Meanwhile the Company remained in a state of uncertainty with regard to their future position in China, and considering the retardation which had taken place, and which left the door open to the unforeseen, they had considered it prudent to deal with the surplus revenue as nearly as possible as in the previous year; and further, to apply a part of that surplus to an increased amortisation of the 1881 Bonds. This measure would be understood by the shareholders when they considered that 5 per cent. is paid on these bonds. The unredeemed amount of the same being only about £40,000 it would hardly be worth the while or the expense to resort to a conversion. With regard to the 1883 Bonds the Company had in this respect no rights before 1898.

China, &c., Inland Enterprises.—The extension of inland Chinese telegraph lines had not progressed much during the past year, but in Corea a land line had at last been constructed and opened for traffic on the 18th July, 1888, to convey messages from the capital of Seoul to Fusan, which place was connected with Japan by means of one of this Company's cables.

Relations with Russia.—The Wheatstone system had been introduced and well organised on the Russian land lines from St. Petersburg to Wladiwostock (the terminal station on the Pacific). The results of the service on these lines had been satisfactory, and no doubt would still improve.

Extension of the Company's Lines.—In accordance with the agreements with the Eastern Extension Company, this Company had become co-proprietors of four short lengths of cable between the Colony of Hong-Kong and the opposite Continent of China at Kowloon. Two of the cables were worked in connecting Hong-Kong with Canton, and the other two served for telephonic purposes between Hong-Kong and Kowloon. The share of this Company's contribution towards the cost of these cables had been taken from

The Reserve Fund.—Out of this fund the cost of spare cable, manufactured in London, had also been defrayed, and it could be expected that the charge under this head might in coming years be larger, owing to the increasing danger to which the cables, particularly those in the North Sea, were exposed by the trawl fishing.

International Scandinavian Exhibition at Copenhagen.—The Company had carried out its intention of exhibiting on that occasion, and the result had been that not only the first prize had been awarded to them for telegraphic and electrical instruments, but that they had also gained a special honourable mention.

Famine in China.—The Company had contributed £500 towards the fund raised in London by the Lord Mayor for alleviating the distress of the sufferers.

The resolutions set out in the Directors' report (which appeared in our last issue) were unanimously passed.

Five shillings per £10 share, representing the final dividend for 1888, is now payable at the Company's bankers, Messrs. C. I. Hambro and Son, 70 Old Broad-street, London, E.C., against coupon No. 15.

The Brazilian Submarine Telegraph Company (Limited).

Report of the Directors for the half-year ended 31st December, 1888, to be submitted to the thirty-first ordinary general meeting, to be held at Winchester House, Old Broad-street, London, E.C., on Wednesday, the 8th inst., at 12 o'clock:—

1. The Directors' accounts and balance-sheet are for the half-year ended 31st December, 1888.

2. The revenue for this period amounted to £133,708. 15s. 1d., and the working expenses to £23,553. 14s. 8d. After providing £12,880 for debenture interest and sinking funds, and £1,985. 6s. 10d. for income tax, there remains a balance of £95,289. 13s. 7d.; to this is added £4,539. 3s. 7d. brought forward from June 30 last, making a total of £99,828. 17s. 2d. First and second interim dividends amounting to £39,000 have been paid, and £40,000 transferred to the reserve fund, leaving the sum of £20,828. 17s. 2d. to be carried to the next account. Of this amount the directors intend distributing £13,000 to the shareholders with and in addition to the quarterly dividend payable in June.

3. In accordance with the provisions for repayment of the first issue of debentures, dated July 31, 1884, 145 bonds, representing £14,500, were drawn on the 12th inst. for payment at par on July 31 next. This, with the previous drawings, will make a total repayment of £65,500, leaving £84,500 of the first issue of debentures outstanding.

4. The question of a reduced rate to Brazil has been under the consideration of your Board for some time, and it has been decided that reductions should be made in the tariff to Madeira, St. Vincent, and Pernambuco. It is anticipated the alteration will at the commencement affect the Company's revenue, but that the growth of traffic resulting from the reduced rates will greatly diminish the possible loss.

5. Under an arrangement with the African Direct, the West African and the Eastern and South African Telegraph Companies, additional traffic will be brought to this Company's lines between St. Vincent and Europe by the new cable now being laid to the Cape of Good Hope.

6. The various sections of the Company's line are in good working order.

The West India and Panama Telegraph Company (Limited).

Report of the Directors and the accounts for the half-year ended 31st December last, to be submitted to the twenty-fourth ordinary general meeting to be held at Winchester House, Old Broad-street, E.C., on Wednesday, the 8th inst., at 3 o'clock:—

1. The amount to credit of revenue is £43,061. 16s. 9d., and the expenses have been £21,425. 1s. 2d., leaving a balance of £21,636. 15s. 7d., which, with the balance of £1,255. 3s. 6d. brought from last account, makes a total of £22,891. 19s. 1d. Of this sum the Directors have placed £1,000 to reserve, leaving an available balance of £21,891. 19s. 1d., with which it is proposed to deal as follows:—

Payment of 12s. per share on account of arrears of dividend on the First Preference shares	£20,737	16	0
Balance to current half-year's account	1,154	3	1
	£21,891	19	1

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2. The traffic receipts for the six months show an increase of £1,050. 9s. 3d., as compared with the corresponding period.

3. The directors are glad to state that comparatively few interruptions of the cables have occurred during the half-year, and that all sections of the company's system are now in working order.

4. The new line of cables mentioned at the last general meeting as having been laid by a French company to connect Santiago de Cuba with Hayti, San Domingo, Curacoa and Venezuela on the coast of South America, was authorised by the Spanish Government to be opened for traffic in February last.

5. Mr. Cyrus W. Field having resigned his seat at the board, the International Ocean Telegraph Company nominated as his successor Mr. George von Chauvin, the representative in England of the Western Union Telegraph Company of America, and the board have elected him a director of the company.

6. In accordance with the articles of association, Henry Holmes, Esq., and Henry Weaver, Esq., retire at this meeting, and offer themselves for re-election.

7. John George Griffiths, Esq., the auditor, also retires, and offers himself for re-election.

The West Coast of America Telegraph Company (Limited).

Report of the Directors to be submitted to the twelfth ordinary general meeting, to be held at Winchester House, 50, Old Broad-street, London, E.C., on Wednesday, May 15th, at 1 o'clock.

The balance-sheet and revenue account show a gross income of £65,714. 15s. 4d. for the year ending 31st December, 1888, against £57,893. 9s. 9d. for the previous year. After deducting debenture interest and all other charges, there remains a nett profit of £30,646. 4s. 6d. for the past year, as compared with £23,114. 18s. 1d. for the year 1887. Adding the amount of £333. 19s. 3d. brought forward, makes a total of £30,980. 3s. 9d. Out of this the following dividends have been paid :—

In July, 1888	4s. per share,	£6,000
In January, 1889	6s. „	9,000
Total		£15,000

The directors now recommend a further distribution of 2s. per share, payable the 16th inst., making 6 per cent. for the year, to write off £500 from the value of the repairing steamer "Retriever," thereby reducing her valuation in the books of the company to £17,000, and to add £12,000 to the reserve fund, making the latter £39,000, which distribution will leave £480. 3s. 9d. to be carried forward. The earnings of the company have been materially increased by a satisfactory state of business in the countries served by its lines. In the month of December the directors purchased an existing land line between Valparaiso and Santiago, which by improved working is already giving good returns on the outlay of capital involved. They have also made arrangements for direct communication between Iquique and Pisagua, a port of increasing importance, by means of a land line. The cables and repairing steamer are kept in perfect working order.

The directors regret to have to report the loss of an esteemed colleague through the death of Mr. Thomas Fielden Campbell. They have filled the vacancy by electing Mr. Frederick Walters to a seat on the board. The members of the board retiring by rotation are Mr. Alfred Marshall and Mr. Frederick Walters; both being eligible, offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs and Co., retires, and is eligible for re-election.

NEW COMPANIES REGISTERED.

BROMPTON ELECTRIC FITTINGS COMPANY (LIMITED).—This company was registered on the 20th inst., with a capital of £2,000, in £1 shares, to manufacture and supply electric light and the fittings for the same, and also electric and other bells, stones, and artistic work in iron, brass, copper, or other metals or materials.

GUTENSOHN AND JAMES.—This company is registered with a capital of £150,000, divided into 15,000 shares of £10 each. The objects of the company (amongst other things) are to purchase, or otherwise acquire, the Royal patents of Gutensohn and James for—(1) an invention for improvements in the process of pickling or cleaning the surface of iron or other metals previous to coating such surface with tin or other metal; (2) an invention of an improved apparatus for pickling or cleaning the surface of iron and other metal, to prepare the same for coating with tin or other metal; and to grant licenses in respect of such patents, and to purchase or hire land and to erect buildings for the purpose of carrying on the company's business of tin plate manufacturers and any other business. The application of electricity to tin plating is, we understand, the improved process referred to.

PATENTEES COMPANY (LIMITED).—This company was registered on the 18th inst., with a capital of £25,000, in £1 shares, to construct public works and conveniences of all kinds, including railways, tramways, wharves, embankments, sewage, drainage, sanitary, water, gas, electric light, telegraphic, telephonic, hydraulic, &c. The number of directors is not to be less than two nor more than seven; qualification, 250 shares; the subscribers are to appoint the first; the company in general meeting will determine remuneration. Registered office, Leadenhall-buildings.

CITY NOTES, &c.

THE ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.—ISSUE OF DEBENTURES.—The directors of the above Corporation invite applications for an issue of £75,000 Six per Cent. First Mortgage Debentures in bonds of £50, £100, and £500 each, upon the security of the whole assets of the corporation, including the uncalled share capital. The subscribed share capital is £237,353, in shares of £5 each, of which 27,057 are fully paid, and 25,517 are only £4 per share paid. The debentures will be issued at par, and will carry interest at the rate of 6 per cent. per annum, payable half-yearly. The debentures will be redeemable at par in 1903, or upon the corporation giving three months' notice in writing, at the rate of 105 per cent. The object of the issue is to obtain funds for extending the business of the corporation.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—The directors recommend a final dividend at the rate of 7 per cent., making, with the interim dividend, a distribution of 6 per cent. for the year ended March 31, 1889, after writing off £2,500 and carrying forward about £1,700. For the previous twelve months the distribution was at the rate of £5. 7s. per cent.

MESSRS. MIX AND GENEST, BERLIN.—The business till recently carried on by Messrs. Mix and Genest has now been constituted under the title of the Actien Gesellschaft Mix and Genest, Telephon-Telegraphen and Blitzableiter Fabrik. The capital in shares amounts to 1,200,000 marks. All the assets of the former firm, namely, 840,000 marks. have been transferred to the new company, and the remaining shares for 360,000 marks have been subscribed for cash payment. There are no mortgage debts or other liabilities. Of the sum paid, 160,000 marks will be reserved for working capital, and the remaining 200,000 marks will be devoted to greatly extending the works, more particularly as regards one of their specialities—the erection and working of telephonic installations. The financing of the company has been undertaken by the banking firm of C. W. Schnoeckel, of Berlin.

MR. SAMUEL ELLIOTT, manufacturer of electric wire casings, of Albert Works, Newbury, has taken offices and show rooms at 63, Finsbury-pavement, E.C.

PERSONAL.—Messrs. Thompson, Ritchie and Turnbull, of Old Broad-street, announce the retirement of Mr. R. O. Ritchie from the firm.

——— We are informed that Messrs. Roothaan, C. M. V. Roothaan and C. Alewijnse, of Nijmegen (Holland), have entered into partnership under the title of Roothaan and Alewijnse. This firm intends to occupy itself principally with the manufacture of incandescent lamps.

——— We are informed that Mr. Arthur W. Slater has withdrawn from the Galway Electric Company and has transferred his interest therein to Mr. James Perry, who assumes all liability in connection therewith, and continues the business on his own account.

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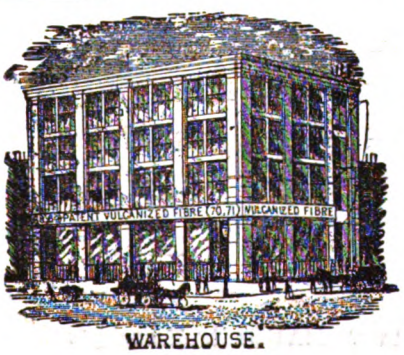

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This new material is supplied in two qualities, Flexible and Hard.

The FLEXIBLE is a substitute for Leather, Rubber, Gutta Percha, &c., and is extensively used by Brass Founders, Axle Makers, Hydraulic, Sanitary, and other Engineers, Pump Makers, Carriage Builders, &c.

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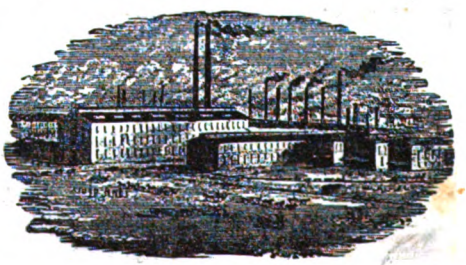
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MOSSES & MITCHELL, 70 Chiswell-st., London, E.C.

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COMPANIES' SHARE LIST.

Present Amount.	Amount of Share.	Last Dividend.	Name	Price, Tuesday, April 30, 1889.	Rate per cent. Yielded.	Dividend Due.	Business Done during Week Ending April 30, 1889.	
					£ s. d.		Highest.	Lowest.
			TELEGRAPHS.					
£ 1,770,360	Stock	15/0	Anglo-American	52 53	3 15 6	Jan., Apr., July, Oct.	52⅞	...
2,614,820	Stock	30/0	Do. Preferred	87 88	4 10 11	,, ,,	88⅛	87½
2,614,820	Stock	...	Do. Deferred	19½ 19¾	...	February	20	19⅜
130,000	£10	5%	Brazilian Submarine	13⅜ 13⅝	5 2 9	Mar., June, Oct., Dec.	13 11/16	13 7/16
112,900	£100	5%	Do. 5 per Cent. Bonds	101 103	4 17 1	January and July	...	...
75,000	£100	3/0	Do. Do. (2nd Series, 1906)	106 109	4 11 9	June and December.	...	...
16,000	10	9/0	Cuba Submarine	14½ 14⅝	6 2 0	February and August	14½	...
6,000	10	10/0	Do. Preference 10%	18½ 19½	5 2 7	,, ,,	...	...
12,931	5	1/7½	Direct Spanish (£4 paid)	3⅜ 4	3 10 0	March & September	...	...
6,000	5	5/0	Do. Preference 10%	8½ 9½	5 5 3	April and October	...	...
60,710	20	3/6	Direct United States xd	10⅜ 10⅝	4 9 3	Jan., Apr., July, Oct.	11⅛	10⅝
380,000	10	2/6	Eastern	13⅛ 13½	4 8 11	,, ,,	13 9/16	13¼
70,000	10	3/0	Do. 6 per Cent. Preference	14⅜ 15¼	3 18 8	,, ,,	15	...
1,200,000	Stock	4%	Do. 4 per Cent. Mortgage Debenture Stock xd	105 107	3 14 9	May and November.	107	106
200,000	100	5%	Do. 5 per Cent. Debentures, 1899	107 110	4 10 11	February & August	...	...
250,000	10	2/6	Eastern Extension	13⅜ 13⅝	4 15 5	Jan., Apr., July, Oct	13 9/16	13 7/16
320,000	100	6%	Do. 6 per Cent. Debentures, 1891	102 104	5 15 5	February & August	104	...
473,000	100	5%	Do. 5 per Ct. (Austrln. Gov. Sub.) Debs. 1900	102 105	4 15 3	January and July	...	...
179,177	10	1/3	Globe Telegraph and Trust	7⅜ 7⅝	4 15 1	Jan., Apr., July, Oct.	7⅝	7 5/16
178,992	10	3/0	Do. 6 per Cent Preference	14½ 14⅝	4 1 4	,, ,,	14⅝	14½
150,000	10	5/0	Great Northern xd	15 15½	4 16 9	Jan., July, and April	15½	15¼
17,000	25	2/6	Indo-European	39 41	6 1 11	April and October	...	...
9,000	8	4/0	Reuter's xd	7 7½	5 6 8	April and October	...	...
15,609	10	3/0	West African Telegraph	7½ 8½	...	...	...	...
300,000	100	5%	Do. 5 per Cent. Debentures	99 102	4 18 0	March & September	...	...
30,000	10	6/0	West Coast of America	9½ 10	5 0 0	January and July	9 1/8	9⅞
150,000	100	8%	Do. Debentures 8%	118 122	6 11 2	June and December	...	...
88,321	10	nil.	West India and Panama	1⅞ 2	...	...	1⅞	...
34,563	10	12/0*	Do. 1st Preference 6%	11⅞ 12¼	...	April and October	12 1/16	11 15/16
4,669	10	†	Do. 6 per Cent. 2nd Preference	12 13	...	...	12 1/16	12
45,181	15	6/0	Western Brazilian	12⅛ 13	5 16 3	March & September	12⅛	12½
1,500	$1,000	7%	Western Union 7 per Cent. 1st Mortgage	117 122	5 14 9	May and November	...	...
187,500	£100	6%	Do. 6 per Cent. Sterling Bonds	100 102	5 17 8	March & September	101¾	...
			TELEPHONES.					
224,850	14/0	4½d.	Consolidated Telephone and Maintenance	⅞ ⅞	...	Yearly	...	...
220,000	£1	3%	Oriental (11s. paid) xd	⅜ ½	3 6 1	...	...	...
80,000	5	5/0	United	15½ 16¼	4 13 7	June and December	16 5/16	16⅛
55,000	5	...	United River Plate	5⅞ 6⅛	...	January and July	6 1/16	6
			ELECTRIC LIGHT.					
23,003	5	...	Anglo-American Brush (£4 paid)	3½ 3⅝	...	...	...	...
23,692	5	nil.	Do. (fully paid)	4¼ 4¾	...	February & August	...	...
79,934	5	nil.	Swan United (£3. 10s. paid)	2½ 3	...	...	3	2⅞
312,000	¼	5% '86	Maxim-Weston	... ...	...	February	...	...
			MISCELLANEOUS.					
37,350	12	36/0	Telegraph Construction and Maintenance	41 43	5 11 9	March and July	42½	41½
41,600	10	10/0	India Rubber, Gutta Percha & Telegraph Works	17½ 18½	5 8 1	February & August	18¾	...

* Account arrears. † No dividend since May, 1880.

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(Being a Patent for "Producing and Dividing Electric Light," No. 1996 of 1877.)

THE UNITED ELECTRICAL ENGINEERING COMPANY (LIMITED)

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